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 group, 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. 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 traditional tools or CAD.
6. Communicate graphically, using sketches, traditional tools, and CAD.
7. Apply technical graphics principles to many engineering disciplines.

What Is Different and Why

Much thought has gone into designing a complete instructional approach to the teaching and learning of engineering and technical graphics. The instructor is provided with a number of tools to assist in the instruction aspects, and the student is provided with tools to assist in the learning process.

This text was written specifically using techniques that will prepare students to use engineering and technical graphics concepts, practices, and modern tools, to solve design problems and communicate graphically. One goal was to provide a textbook that was clear, interesting, relevant, and contemporary.

Some of the distinguishing features of this text include the following:

1. *Modern topics*—The book is filled with modern examples, illustrations, and industry examples so students can relate to the material being presented.
2. *Emphasis on visualization*—Integrated throughout the text are visualization topics, explanations, and assignments to constantly reinforce and improve the student's visualization skills.
3. *3-D modeling chapter*—This *unique* chapter is devoted exclusively to the theory and practice of 3-D modeling.
4. *Modern parts used for problem assignments*—Most end-of-chapter problems are parts or assemblies of modern devices and products.
5. *Integration of CAD*—CAD concepts and practices have been integrated through all the chapters when they are relevant to the topic. They are not simply "tacked onto" the end of a chapter.
6. *Integration of design*—Design concepts are integrated through the text to give relevance and understanding of the relationship of design to technical graphics.

Coverage of Modern Topics

One of the primary reasons we wrote the text is that many modern topics either are not found or not covered in sufficient detail in traditional texts. Examples of contemporary topics covered in this book include:

Computer simulation
Mechanism analysis
Human factors
Product data management (PDM)
Design for manufacturability (DFM)
Knowledge-based engineering (KBE)
Virtual reality (VR)
Visualization
3-D modeling problems, concepts, and practices
Coordinate space
Product Lifecycle Management (PLM)
Multiviews from 3-D CAD models
Right-hand rule
Polar, cylindrical, spherical, absolute, relative, world, and local coordinate systems
Freeform curves
Spline curves
Bezier curves
Geometric surfaces
Double-curved surfaces
NURBS
Fractals
IGES
PDES
Missing lines
Concurrent engineering
Collaborative engineering
Designer's notebook
Contour sketching
Upside-down sketching
Negative space sketching

Extensive Coverage of Traditional Topics

Even though we firmly believe our coverage results in the most modern text available, we have been very careful to include all the traditional topics normally found in a technical drawing textbook. Students must learn the fundamentals whether using hand tools or CAD to communicate graphically. Therefore, coverage of traditional topics is comprehensive and in many cases includes step-by-step procedures and enhanced color illustrations to facilitate teaching and learning. The text includes the latest ANSI standard practices used in industry. Following are some of the major traditional topics covered in detail in this text.

Orthographic projection
Descriptive geometry
Intersections and developments
Geometry and construction
Isometric drawings
Oblique drawings
Auxiliary views
Section views

- Multiview drawings
- Dimensioning
- Geometric dimensioning and tolerancing (GDT)
- Working drawings
- Gears, cams, and bearings
- Welding drawings

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 in the Online Learning Center (OLC) 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 in the Online Learning Center 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 4.10). 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

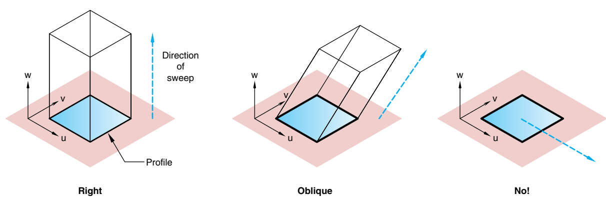


Figure 4.10 Types of linear sweeping operations

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

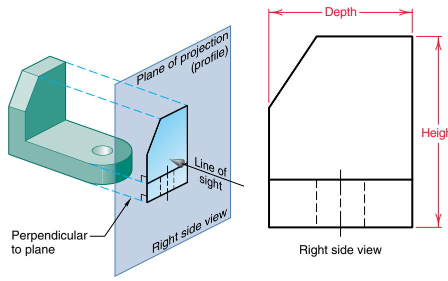


Figure 5.10 Profile view

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

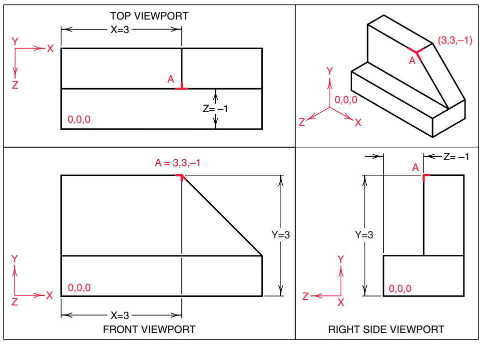


Figure 3.6 Display of coordinate axes in a multiview CAD drawing

Only two of the three coordinates can be seen in each view.

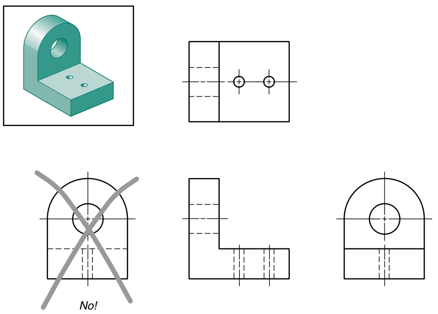


Figure 5.43 Most descriptive views

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.

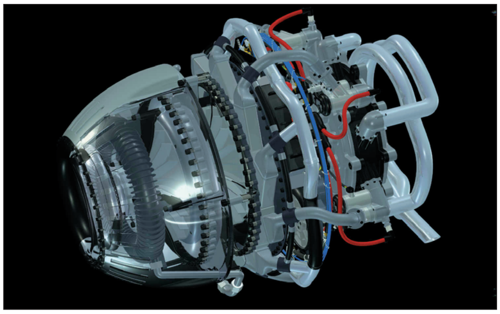


Figure 1.42 **High-resolution rendered image of a CAD model**

(Courtesy of Simon Floyd Design Group.)

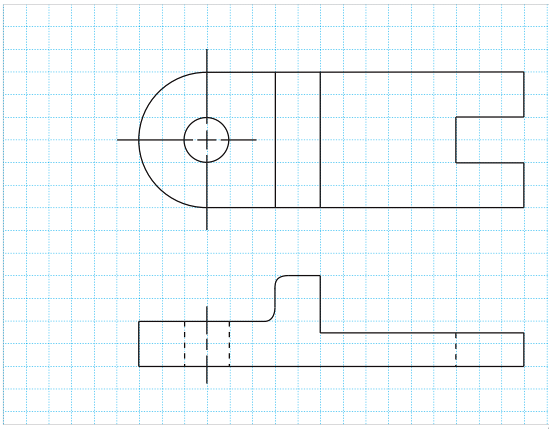
text illustrations in many different colors is a huge advantage when teaching engineering and technical graphics.

Photographs and grabs of computer screens are much more interesting and show much more detail when in color (Figure 1.42). 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 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 presented as a boxed item 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. Through the Design in Industry boxes, students will learn how design is done in industry from interesting stories presented by practicing engineers and technologists. For example, Chapter 12, "Geometric Dimensioning and Tolerancing (GDT)," includes a Design in Industry application that features an accelerated design process used by designers at Stryker Medical to create the Trio Mobile Surgery Platform, a tool that provides a safe and efficient means of trasfer for heavier, elderly, or sedated hospital patients. In this example, the student learns how the effective use of CAD tools enabled the design team to see the immediate impact of their design variations and construct four prototypes in a two-year span, enabling the final product to be put on the market more quickly. This feature also will give students an increased awareness and appreciation for the role of graphics in engineering design.

Practice Problem 9.1

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



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

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.

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. These step-by-step procedures show the student in simple terms how a drawing is produced. Most of the illustrations accompanying the step-by-step procedures are in multiple parts so the student can see how the drawing is created. In many cases, the color red is used in each step of the illustration to show what is being added or created. This effective use of color draws the attention of the student so there is less chance for confusion or making errors when they reference the illustration and steps, or when given drawing assignments.

Integration of CAD Every chapter includes specific references to CAD rather than simply adding them to the end of the chapter. By integrating the references in the text, the student learns how CAD is used in the context of the topic being explained. Students begin to understand that CAD is another tool used by the engineer and technologist to communicate. Traditional topics and CAD topics are integrated seamlessly because the text was written that way in its first edition. CAD is not an add-on or afterthought. It is integrated fully and embraced as a means of creating graphics for engineers and technologists (Figure 5.35).

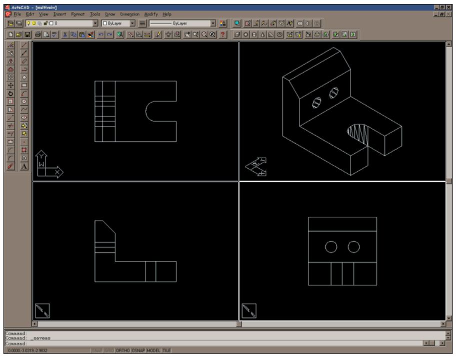


Figure 5.35 Predefined multiviews on a CAD system

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.

Historical Highlights This chapter feature includes information about important events and people in the history of graphics. Historical Highlights are presented as a special boxed feature that contains an overview of the person or event along with photographs and drawings. They are used as a means of giving the student an historical context to graphics. Students will gain an understanding of the slow evolution of the "science" of graphics as it was painstakingly developed throughout the history of humankind.

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 all 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. The Further Reading list can be useful for the instructor seeking additional information about a topic. Students will also find it useful to supplement their reading, studying, and learning.

Tear-Out Worksheets To give students extra drawing and sketching practice, this edition includes dozens of perforated worksheets. The questions and directions for the worksheets are found under "Workbook Problems" at the end of each corresponding chapter. For instance, in Chapter 3, "Engineering Geometry," the workbook problems have students sketch a ridge gasket and centering plate (on the given rectangular grid), plot coordinates, and cut out the patterns in 3-D cubes and prisms.

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. All 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, Workbook Sheets, Appendixes, and Index

At the end of the text is an extensive glossary containing the definitions of all 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, 5th 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.

The perforated drawing workbook sheets, described earlier in the "Tear-Out Worksheets" section, are found after the index.

Online Learning Center (OLC)

The OLC Website follows the textbook chapter by chapter. As students study, they can refer to the OLC 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 Instructor's Manual, Solutions Manual, and presentation materials are now just a couple of clicks away. You will also find additional problem material and exercises.

OLC Supplements

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

Learning Objectives A listing of all learning objectives for each chapter in the text.

Chapter Outline An extensive outline of each chapter.

Multiple-Choice Quiz An interactive online quiz covering important topics in the chapter. Answers are submitted for automatic and immediate grading for review by the student.

Questions for Review The questions include a hint button if a student cannot answer the question. The hint button refers the student to the chapter page where the material relevant to answering the question can be found.

True or False Questions An interactive online true and false test covering important topics in the chapter. Answers are submitted for automatic and immediate grading for review by the student.

Key Terms Key terms from each chapter are listed with their definition and page reference from the text.

Flashcards Interactive exercises to assist students in learning important terms from each chapter of the text.

Website Links Many chapters include numerous website links that can be used by students and faculty to supplement the textbook material.

Animations Many chapters include animations that can be downloaded and played on a computer showing how to visualize and understand concepts.

- 2-D coordinates—animation showing 2-D coordinate concepts such as origin, X and Y axes, and ordered pairs.

- 3-D coordinates—animation showing 3-D coordinate concepts such as origin, X and Y and Z axes.
- Right-hand rule—animation showing “finger” relationship to axes and positive rotation concepts.
- Glass box—animation showing the glass box projection concept.
- World and local coordinates—world and local coordinate concepts
- Section views—animations showing the concept of section views.

Related Readings A listing of additional books that can be used as references or further reading on topics covered in the chapter.

Image Library The image library contains all the images in each chapter that can be viewed, printed, or saved to disk.

AutoCAD Exercises Some chapters contain additional mechanical, civil, and architectural AutoCAD problems in PDF format for viewing and printing hard copies. These problems include step-by-step procedures useful in drawing the problem using AutoCAD software.

Career Opportunities An extensive list of links to websites containing job opportunities.

Visualization Exercises Some chapters include links to additional visualization exercises that students can use to improve their understanding and ability.

Stapler 3-D Modeling Project 3-D modeling projects are included in the Online Learning Center. The purpose of the integrated 3-D modeling project is to further assist and motivate students to learn engineering and technical graphics concepts through a real project. The 3-D modeling project uses a real product, a stapler made by Swingline. The instructor and student are given information in Chapter 1 on the exact type of stapler to purchase, which will be reverse engineered. The stapler is a fairly simple device with some challenging surfaces. The range of complexity allows students to begin with simple parts and move on to increasingly sophisticated graphics and models as they become more knowledgeable and experienced in using computer graphics.

The stapler project can be assigned to each student or to small teams. Students can begin to experience the design process by redesigning the stapler given some parameters or by receiving an engineering change order. Virtually every major topic covered in the text can be related to the stapler project, such as dimensioning, section views, multiviews, sketching, 3-D modeling, design, working drawings, geometry, tolerancing, surface modeling, assemblies, pictorial views, simulation, and renderings. The culmination of the project could be a presentation of their stapler project redesign and the documentation produced throughout the semester or term by each student or the group. This project can be a powerful tool to motivate and enhance learning by all students. It can serve as an excellent resource for the instructor to supplement lectures and laboratory assignments and can result in better learning and retention by students.

Case Studies Interesting case studies for each chapter describing how CAD is used in the real world.

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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.

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