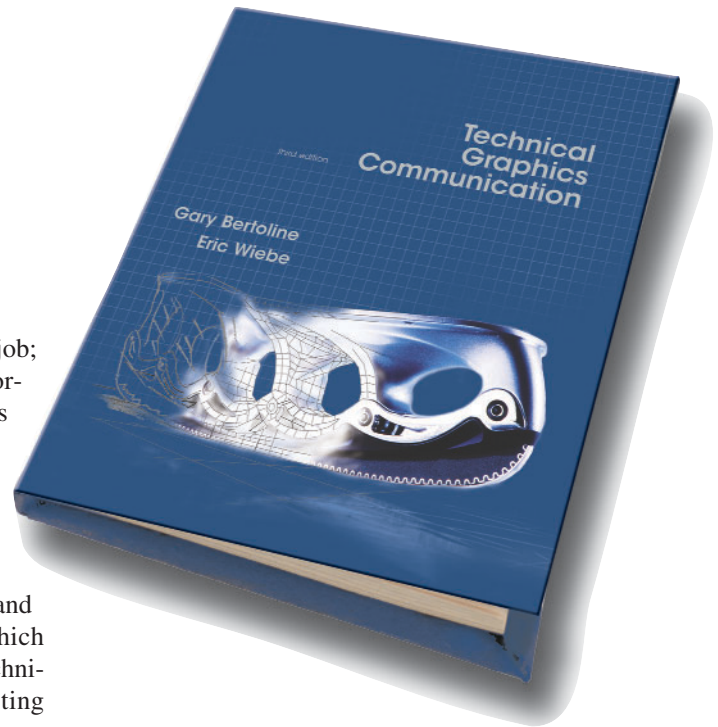# Preface

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 and technologists 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.

Engineering and technical graphics have gone through significant changes in the last decade as a direct result of 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.

This new-generation graphics text is therefore 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. Much of this text is still dedicated to the instruction of graphics using hand tools, but the instruction is generic so that either hand tools or computers can be used.

In Chapter 20, "Design in Industry," 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 engineering and technical graphics.

Goals of the Text

This text was written 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 to use both hand tools and 2-D or 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 teaching and learning of 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 specifically written using techniques that will prepare students to use technical graphics concepts, practices, and modern tools, to solve design problems and communicate graphically. One goal was to provide to the students a textbook that was clear, interesting, relevant, and contemporary.

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

1. 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.

2. Visualization chapter—This *unique* chapter, devoted exclusively to visualization, assists the student in understanding the concepts and importance of visualization and offers techniques for reading and visualizing engineering drawings.

3. 3-D modeling chapter—This *unique* chapter is devoted exclusively to the theory and practice of 3-D modeling.

4. Modern topics—The book is filled with modern examples, illustrations, and industry examples so students can relate to the material being presented.

5. Modern parts used for problem assignments—Most end of chapter problems are parts or assemblies of modern devices and products.

6. Emphasis on visualization—Integrated throughout the text are visualization topics, explanations, and assignments to constantly reinforce and improve the student's visualization skills.

7. Integration of design—Design concepts are integrated through the text to give relevance and understanding of the relationship of design to technical graphics. This is visually reinforced throughout the text through the use of an icon located in the margin of the text whenever a design concept is covered. The icon is a smaller version of the Concurrent Engineering Design Process figure first introduced in Chapter 2. Figure 2.8 breaks design into three major components: ideation, refinement, and implementation. Whenever one of these topics is discussed in the text, a smaller version of Figure 2.8 is placed in the margin with ideation, refinement, or implementation highlighted. This lets the student know that the topic being covered is relevant to the engineering design process and constantly reinforces design as the underlying theme for engineering and technical graphics.

Ideation   Refinement   Implementation

Coverage of Modern Topics

One of the primary reasons we wrote the text is that many modern topics are either 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 problems
Coordinate space
Right-hand rule
Polar, cylindrical, spherical, absolute, relative, world, and local coordinate systems.
Freeform curves
Spline curves
Bezier and B-spline curves
Geometric surfaces
Double curved surfaces
NURBS
Fractals
Data exchange standards
IGES
PDES
3-D modeling problems
Multiviews from 3-D CAD models
Missing lines
Concurrent engineering
Design for manufacturability (DFM)
Collaborative engineering
Designer's notebook
Contour sketching
Upside-down sketching
Negative space sketching
3-D modeling concepts and practices

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. The authors fully understand that 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. Listed below are some of the major traditional topics covered in detail in this text.

Orthographic projection
Descriptive geometry
Intersections and developments
Reading scales
Traditional tools
Geometry and construction
Isometric drawings
Oblique drawings
Auxiliary views
Section views
Multiview drawings
Dimensioning
Geometric dimensioning and tolerancing (GDT)
Fastening devices and methods
Working drawings
Gears, cams, bearings, and linkages
Electronic drawings
Piping drawings
Welding drawings

Chapter Overviews and Features

Every chapter has been carefully planed and written with a consistent writing, illustration, design style, and pedagogy. Students and instructors will quickly learn 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.

To accomplish these goals, the text is divided into 5 parts and 25 chapters. Each part has a brief introduction with a listing of chapters in the part so the instructor and student understand the logical sequencing of topics and chapters. Each chapter has a logical sequence and organization that is easily followed by the instructor and student. Each chapter contains these features:

Relevant Quotes   Each chapter opens with a quote that is relevant to the chapter material being covered or the topic of graphics in general. These quotes, many by famous historical figures, reinforce the importance of graphics in

industry and society. For example, Chapter 5's Visualization in Design quote, "I shut my eyes in order to see" by Paul Gauguin, the famous artist, is very relevant to the topic being covered in the chapter. Visualization is a mental process frequently used in the design process and in the creation of graphics to describe a new design.

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 can also use the objectives as a guide when writing tests and quizzes. The tests and quizzes included in the supplements 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.

Introduction   A brief overview of the chapter contents prepares the student for the material to be presented. The introduction sets the stage for the relevancy and importance of the material to be covered for the engineer or technologist. The introduction includes a rationale explaining why it is important to learn the material in the chapter. For example, the introduction in Chapter 4, "Sketching and Text," includes this statement: "Sketching is an important method of quickly communicating design ideas; therefore, learning to sketch is necessary for any person working in a technical field." Students now understand why it is important to study and practice sketching before they learn the material.

Color Is Important in a Modern Engineering and Technical Graphics Textbook   This is the first technical graphics textbook to use four-color illustrations throughout to better present the material and improve learning. The selection and use of color in the text is consistent to enhance learning and teaching. *Many of the color illustrations are also available to the instructor in the image library found in the Instructor Resources to supplement lectures, as explained in detail later in this Preface.*
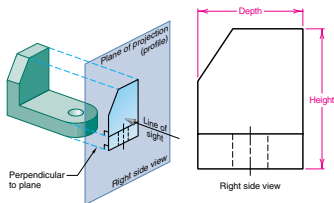
The use of color in the text was done specifically to enhance teaching, learning, and visualization. Workplanes are represented as a light pink (Figure 7.26).
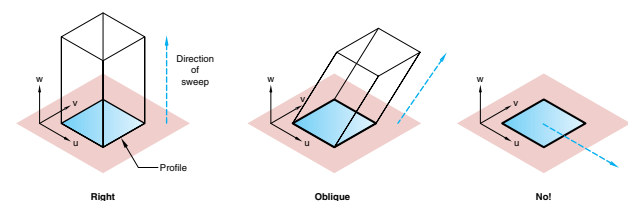
Figure 7.26

Types of linear sweeping operations
In some systems, linear sweeps are restricted to being perpendicular to the workplane.
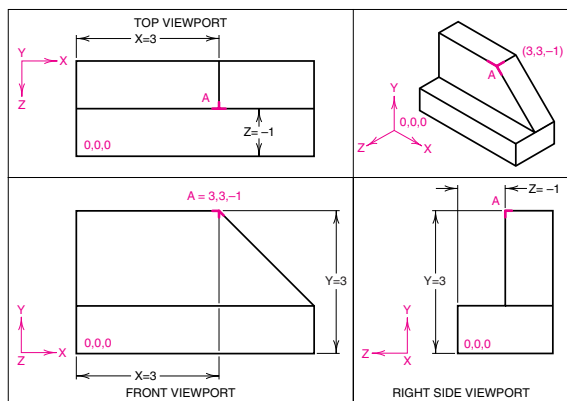
Figure 8.10

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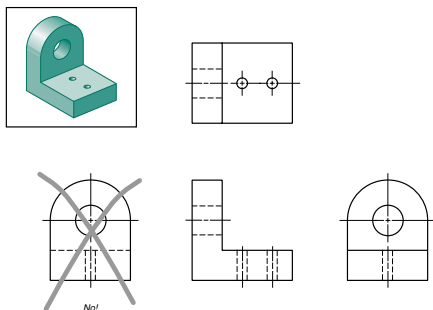A right side view of the object is created by projecting onto the profile plane of projection.

Projection and picture planes are a light purple color (Figure 8.10).

Important information in a figure is shown in red to highlight the feature and draw the attention of the reader (Figure 6.6). Color shading is often used on pictorial illustrations so the user can better visualize the 3-dimensional form of the object (Figure 8.43). This is especially impor-

tant 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.

Frequently, different shades of color are used on objects to highlight various features, improve visualization of objects, and better describe them (Figure 6.48). Different shades of color are also used on a single object to highlight surface features, which is useful especially when trying to draw attention to certain features, such as holes, oblique planes, and surfaces to be projected onto a picture plane. **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.** Effective use of color improves the pedagogy and can greatly enhance an instructor's lecture and ability to teach complicated or hard to understand concepts. Being limited to one or two colors as in other texts is an unnecessary obstacle to effective teaching and learning.

Photographs and grabs of computer screens are much more interesting and show much more detail when in color (Figure 1.11). 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. Showing a black and white illustration to explain finite element analysis is just short of being useless. CAD

Figure 6.6

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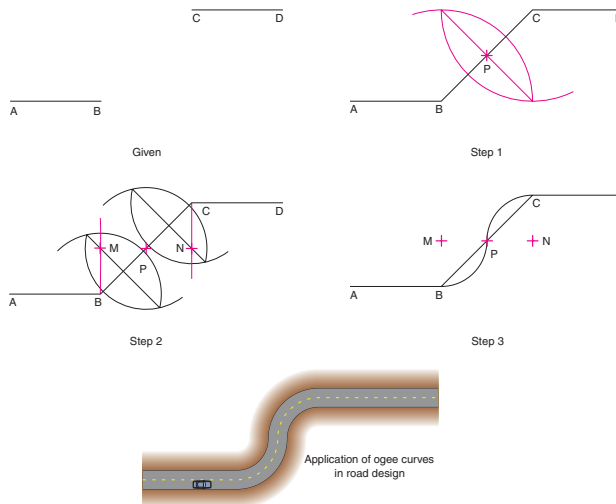

Figure 8.43

Most descriptive views
Select those views which 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 6.48

**Constructing an ogee curve between two parallel lines**

Figure 1.11

A refined 3-D model of a bicycle used to communicate the design without ambiguity.
(Courtesy of Alventive, Inc.)

systems are capable of displaying millions of colors and can create photographic realistic models of designs and assemblies. Full-color illustrations in engineering and technical graphics should be a standard for all texts.

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 4.1 in Chapter 4, "Sketching and Text," 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 also 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.
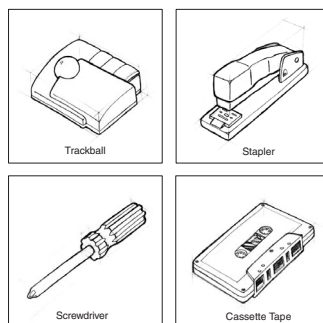
Figure 4.37

Isometric sketches of common objects

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.
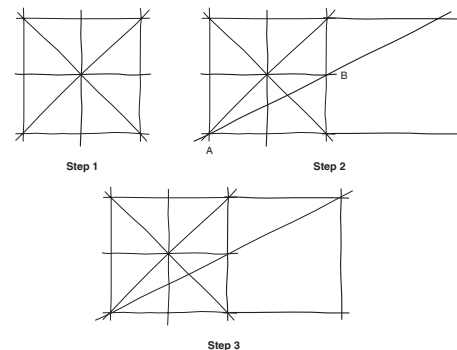
Figure 4.22

Sketching identically proportioned squares
An identically proportioned square is created by extending both top and bottom horizontal lines and constructing diagonals across the existing box.

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. In some cases whole sections or chapters deal with CAD topics. For example, Chapter 7, "Three-Dimensional Modeling," covers the use of CAD to create 3-D models. Students begin to understand that CAD is another tool used by the engineer and technologist to communicate. Traditional topics and CAD topics are seamlessly integrated because the text was written that way in its first edition. CAD is not an add-on or afterthought. It is fully integrated and embraced as a means of creating graphics for engineers and technologists (Figure 8.35).

Historical Highlights   The chapters in the first half of the text include information about important events and people in the history of graphics. This is an extension of the history of graphics first introduced to the students in Chapter 1. Historical Highlights are presented as a special
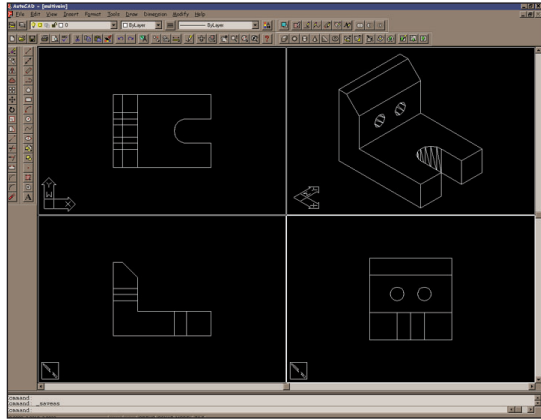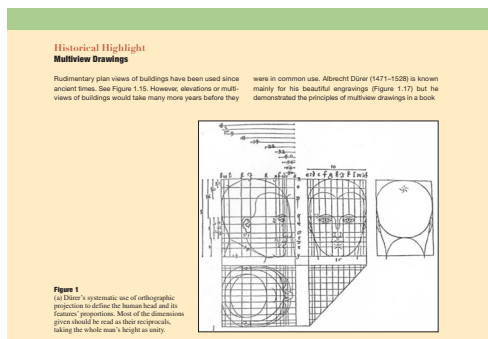
Predefined multiviews on a CAD system

Design in Industry
Concept to Victory in 7 Months

Designing a Winning Tour de France Bike
The courageous story of recovering cancer victim Lance Armstrong centered the world's attention on the US Postal Service team in the 2000 Tour de France® bicycle road race. Could Armstrong repeat his win and wear the yellow jersey again? Not only did he emerge victorious from the Tour de France, but just a month later he captured a bronze medal at the Sydney, Australia, Summer Olympics™.

You might think the bicycle a champion like Armstrong rides would take a long time to develop, with a team of engineers puzzling over the design, tweaking and re-tweaking time after time. The USPS Team Time Trial carbon fiber bike, made by world class bicycle manufacturer, Trek® Bicycle, moved from initial concept to finished product in just seven months. "That's a first," said Michael Sagan, Industrial Designer of Trek's Advanced Concept Group. "Normally it takes 12 to 14 months to complete a project like this."

A Single Prototype
Sagan believes Trek was able to achieve the dramatically fast turnaround in large part because the company had the right people and the right computer tools. Trek has been using Alias|Wavefront™ Studio™ for the past five years and for this project the company moved to an NT system and paired it with the latest release of Studio.

Sagan used the new integrated paint function in Studio to sketch out different 3-D views of the bike's frame over Pro-E

centerlines created by Trek Lead Engineer Doug Cusack. After concepts were reviewed and a direction decided, a complete 3-D digital frame was created. Advanced Concept Group modelmakers used the digital information to cut a phenolic resin prototype using SurfCAM. Then the prototype was taken to Texas A&M University for wind tunnel testing.

The test was conducted by aeronautical engineer, John Cobb and Cusack, with Armstrong riding the experimental model in the tunnel. Variations were tried by adding clay to the model, but the original prototype delivered the best performance. "We nailed it right off the bat," said Sagan. "We did make more changes later to improve the lateral stiffness, but we had such a high confidence level in our digital model that we didn't feel the need to make another prototype and could proceed directly to tooling. It really was a concept to victory."

About the Bike
The USPS Time Trial bike frame is made of Optimum Compaction Low Void carbon, a compressed super light fiber. OCLV minimizes air pockets and maximizes strength. The only thing close to it is a fighter aircraft wing. The frame features an aerodynamic downtube, a steeper seat tube and flared chain stays for a power-generating and wind-splitting riding position. The complete design results in a bike that is not only fast, light and strong, but also more comfortable for the rider.

(Courtesy of Michael Sagan, Industrial Designer, Trek Bicycle Corp.)

Historical Highlight
Multiview Drawings

Rudimentary plan views of buildings have been used since ancient times. See Figure 1.15. However, elevations or multiviews of buildings would take many more years before they

were in common use. Albrecht Dürer (1471–1528) is known mainly for his beautiful engravings (Figure 1.17) but he demonstrated the principles of multiview drawings in a book

Figure 1
(a) Dürer's systematic use of orthographic projection to define the human head and its features' proportions. Most of the dimensions given should be read as their reciprocals, taking the whole man's height as unity.

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. Most of the Historical Highlights are directly related to the content of the chapter. For example, in Chapter 8, "Multiview Drawings," the Historical Highlight features work by Albrecht Dürer in the late 1400s and early 1500s on developing orthographic projection.

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
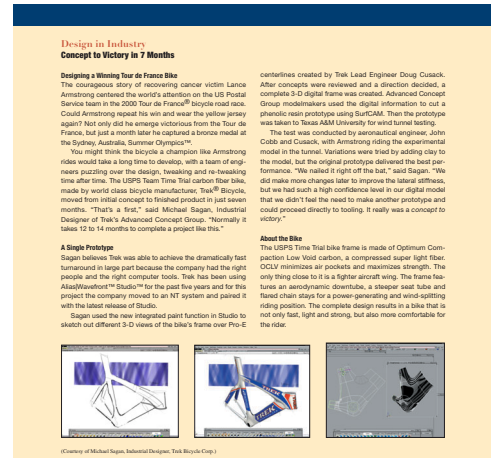
to supplement the information presented. Through the Design in Industry boxes, students will learn how design is done in industry through interesting stories presented by practicing engineers and technologists. For example, Chapter 4 includes a Design in Industry application that features an accelerated design process used to create a more aerodynamic bicycle for Tour de France champion Lance Armstrong. In this example, the student learns how, through effective use of CAD tools and simulation software, it was possible to cut the normal design process for new bicycle design from 12 to 14 months to 7. This feature will also give students an increased awareness and appreciation for the role in graphics in engineering design.

Highlighting Key Terms   Important terms are highlighted in each chapter with bold or italicized text. All boldfaced terms are included in the extensive glossary found at the end of the text for easy reference. Italicized text draws the attention of the reader to highlighted important terms or phrases. These highlighted key terms are especially useful for students when studying for tests and quizzes and they introduce and reinforce the technical language associated with engineering and technical graphics.

Summary   Each chapter ends with a summary as a means to pull everything covered in the chapter together for the student. The summary is a brief overview of the most important topics covered in the chapter. In some cases, the summary also includes important information listed in tables or bulleted lists. For example, as part of the Summary for Chapter 12, "Fundamentals of Descriptive Geometry," is a table listing tips on solving different types of descriptive geometry problems and a table listing 11 descriptive geometry facts.

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 to find additional information about a topic. Students will also find it useful to supplement their reading, studying, and learning. For example, although perspective drawings are covered in good detail in Chapter 9, "Axonometric and Oblique Drawings," the Further Reading list includes two texts, one the classic reference for technical illustration by Thomas, that can be used to give more depth to lectures and assist those students wanting to learn more about perspective drawings.

Stapler 3-D Modeling Project   Beginning in Chapter 4, "Sketching and Text," 3-D modeling projects are included at the end of several chapters. 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 4 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 the student to begin with simple parts and move onto increasingly sophisticated graphics and models as they become more knowledgeable and experienced in using computer graphics.

This project is meant to run concurrently throughout the text as a means of giving relevance and consistency to the learning of engineering and technical graphics. As new topics are introduced, the instructor can use the stapler as a "hands-on" example to supplement their lectures and laboratory assignments. For example, when covering topics in Chapter 17, "Fastening Devices and Methods," the stapler can be used to supplement the lecture by allowing the instructor and student to share what type of fasteners and how they are used in the stapler. One assignment for that chapter might be to ask the students to look in a catalog for the fastener used in the stapler and begin or add it to the parts list.

The stapler project can be assigned to each student or to small teams. Students can begin to experience the design process, re-designing the stapler given some parameters or by assigning 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, serve as an excellent resource for the instructor to supplement lectures and laboratory assignments, and result in better learning and retention by students.

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. Most chapters include problems with figures that students are to solve or replicate using traditional tools and CAD. 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
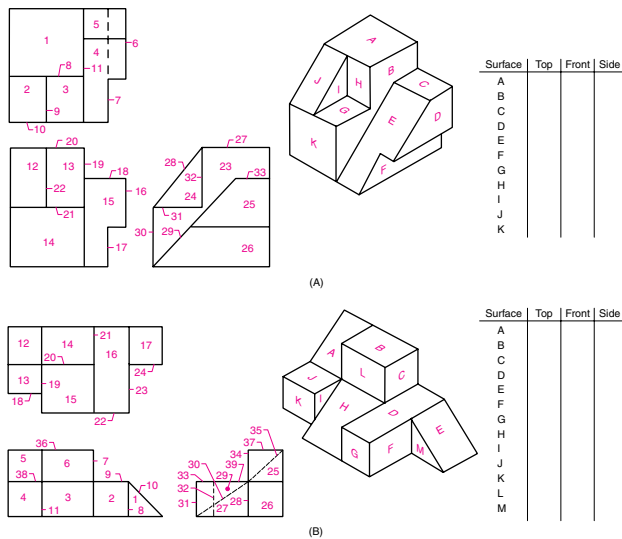
Figure 5.62

today. There are many examples of *unique* problems that are not found in other textbooks. For example, many of the problems in Chapters 5 and 7 are not found in other engineering and technical graphics texts. These problems reinforce student learning and give them experience that will be of great value in industry.

The wide range and numerous 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.

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.
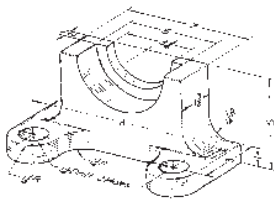

Figure 8.172

Bearing rest

Part 1
Visual Science for Technical Graphics

This section contains five chapters that introduce the student to engineering design graphics. It includes an explanation of the importance of graphics instruction for engineers and technologists, has a brief overview of the engineering design process, explains the tools used to communicate graphically, shows how to create simple sketches, and explains visualization in the context of engineering design.

Chapter 1, "Introduction to Graphics Communications," looks at the past, present, and future to explain the role and importance of graphics communications in engineering design. The concept of visualization is first introduced to the student so they can begin to relate its importance to design graphics. There is a strong emphasis on communications in this chapter so students begin to understand that graphics is a powerful form of human communications. A brief history of graphics is included which is supplemented in many other chapters through the Historical Highlights. The strength of the chapter is that students will get an overview of the context and importance for studying and learning engineering design graphics. This chapter sets the tone and rationale for the remainder of the book. One *unique* feature of the chapter is Practice Exercise 1.1, which shows through a simple exercise why graphics communication is the only useful method of describing design and the power of graphics over the written or spoken word.

Chapter 2, "The Engineering Design Process," was significantly changed for the 3rd Edition. Much of the original content was moved to a new Chapter 20, and new material was added. Chapter 2 is a brief introduction to traditional and modern technical design methodologies. One *unique* aspect of this chapter is the explanation of the modern practices used in engineering design, in which engineers interact and communicate with other professionals in the company. A significant addition to this chapter is the coverage of the internet, e-business, and the digital enterprise and how it impacts the design process and engineers and technologists.

Chapter 3, "Technical Drawing Tools," is an introduction to the traditional and modern tools used to create sketches, drawings, and computer models. The chapter begins by describing, in simple terms, the computer hardware and peripherals commonly used for CAD systems. Traditional tools are described, with step-by-step instructions on how to use them. The instructions also cover how CAD is used to supplement traditional tools. This is the first chapter employing one of the major features of this

text: step-by-step instructions. There is extensive coverage in the use of scales, which remain an important tool even when using CAD. Students are shown exactly how to read various scales through effective use of illustrations and end of chapter problem assignments.

Chapter 4, "Sketching and Text," is an introduction to the creation of sketches and their use to support the design process. Traditional sketching tools are described, along with important sketching techniques. Step-by-step procedures guide the student through simple sketching activities. Students are introduced to proportioning, ellipses, and multiview and pictorial projection techniques.

New to the third edition are additional techniques useful to learn and improve sketching technique not covered in other technical graphics texts. The additional sketching techniques are similar to those found in the classic text, *Drawing on the Right Side of the Brain* by Betty Edwards, and includes contour sketching, negative space sketching, and upside-down sketching. All of these techniques can dramatically improve a person's ability to make sketches. These techniques are reinforced through end of chapter sketching assignments.

This chapter also is the first time the student is introduced to the Stapler 3-D Modeling project where the assignment is to disassemble the stapler and make sketches of each part. The problems begin with a very useful list of Hints for Isometric Sketching and Hints for Multiview Sketching. There are over 100 problems at the end of the chapter ranging from the very simple to complex in terms of difficulty and range of geometry used in the object.

Chapter 5, "Design Visualization," is a *unique* chapter aimed at helping students improve their visualization abilities, which are fundamental to understanding and creating technical graphics. This chapter is unlike anything found in other technical graphics texts. The authors, through their teaching experience and cognitive visualization research, believe this is an extremely important chapter for students and instructors. The chapter briefly explains the human visual systems so students understand the complexity and power of human visualization.

The chapter quickly moves into the very basics of visualization as it related to engineering design graphics. The nomenclature and techniques used to describe objects are explained in detail so students understand the language of engineering and technical graphics. This leads into extensive coverage of the visualization techniques employed for technical drawings, such as image planes and orientation. Students get their first introduction into inclined, normal, and oblique lines and planes. Examples are kept very simple so students can grasp the elementary concepts

in preparation for the application to more sophisticated objects.

Integrated into the chapter is information about data visualization and the use of graphs and charts to describe and visualize engineering data. Another *unique* feature of this chapter is the extensive coverage of VR in Section 5.8, "Virtual Reality and Visualization." In this section the students gain an understanding of how virtual reality will impact engineering design and how it is used as a visualization tool.

Finally, the extensive and *unique* problem sets at the end of the chapter reinforce visualization techniques and concepts, such as rotation, paper folding, cutting planes, surface identification, pattern recognition, and orientation. Many of the problems are taken from common visualization tests or have been modified for use in this text. These exercises prepare students to better understand and more quickly learn concepts covered later in the book, such as section views, multiviews, isometric projection, auxiliary views, descriptive geometry, intersections, development, and 3-D modeling.

Part 2
Fundamentals of Technical Graphics

This part shows students how to construct 2-D and 3-D geometry and create multiview and pictorial technical drawings.

In Chapter 6, "Engineering Geometry and Construction," the student is shown how to create and edit 2-D geometry, using both traditional tools and CAD. More advanced technical geometry that can be created with 3-D CAD is also introduced. This chapter includes an extensive explanation of coordinate space which is especially useful for 3-D CAD. Another *unique* aspect of this chapter is the extensive coverage of geometric principles, such as parallelism, intersections, tangencies, and comprehensive coverage of 2-D and 2-D geometry. Although there is much coverage of creating geometry using traditional tools and techniques, students learn about the fundamental geometric forms which is valuable when using CAD. Many geometric forms covered in this chapter are also put into a real-world context through examples, such as how parabolas are used in the design of radio telescopes and bridge supports. Extensive coverage of more advanced geometric forms, such as splines, surfaces of revolution, swept surfaces, ruled surfaces, convolutes, Bezier surfaces, and fractals is included in this chapter. This *unique* coverage provides students with the basic understanding

of more complex geometry necessary for creating 3-D surface geometry with CAD.

Chapter 7, "Three-Dimensional Modeling," is an extensive coverage of 3-D modeling theory, techniques, and applications. The chapter shows how computers are used to create all types of 3-D models, using various construction techniques. Coverage includes wireframe, surface, and solid modeling, constraint modeling, constructive solid geometry modeling CSG, and boundary representation modeling. Feature analysis is explained so students begin to understand design intent which is so important when concerned with modern engineering design. A section on feature definition explains how to build models using various features defined by the user. There is extensive coverage of how to create 3-D geometric models using a number of techniques, such as linear sweeping, revolved sweeping, Boolean operations, the use of workplanes, and sketching the profile. Virtually every method and technique used to create 3-D models with CAD is covered in the chapter, giving the student the understanding necessary to use any 3-D modeling system. More advanced topics include parts management, ergonomics, computer-aided manufacturing (CAM), data associativity, data exchange standards, and model analysis such as kinematics, clash detection, FEA, and mass properties analysis. Many of these important topics are completely absent from other texts. The authors of this text have gone to great lengths to truly integrate traditional and modern engineering design graphics theory and practice into a single text. Chapter 7 is a powerful example of this true integration that users will find very useful in understanding the transition taking place in industry. Even the end of chapter problems are an integration of traditional and modern, having many problems that directly relate to 3-D modeling concepts and construction techniques.

Chapter 8, "Multiview Drawings," introduces standard multiview drawings for technical design and production. The chapter begins by explaining projection theory in general and multiview projections in particular. Standards and conventional practices for multiview drawings are then introduced. Integrated into the chapter are explanations and the use of illustration to assist the learner in visualizing the principles of orthographic projection. These visualization techniques provide a solid foundation and understanding of orthographic projection and how it relates to creating multiview drawings. There is even extensive explanation as to why multiview drawings and orthographic projection are necessary when communicating engineering designs. Integrated into the chapter are the eight rules for orthographic projection. This list, developed by the authors, provides students with eight

guiding principles of orthographic projection which will help students understand and more easily learn the techniques and practices of multiview drawings. The authors go to great length in this chapter to explain techniques that can be used to visualize 3-D objects and 2-D multiview drawings, such as projection studies, model construction, analysis of solids, adjacent areas, similar shapes, surface labeling, missing lines, and vertex labeling. Finally, the end of chapter problems are very extensive and varied in their type and difficulty. Visualization is again reinforced through selected problems, such as surface labeling, and missing view and missing line problems.

Chapter 9, "Axonometric and Oblique Drawings," is an introduction to such drawings and contains an in-depth discussion of pictorial projections and drawings, building on the material covered in Chapter 4, "Sketching and Text." Through step-by-step instructions, the student is shown how to create pictorial drawings, using traditional instruments or CAD. This chapter also goes to great lengths to explain the theory and technique of axonometric and oblique drawings so students understand at a very fundamental level how these projection techniques are created. This serves as a solid foundation for further study and for learning the techniques developed to represent objects in isometric and oblique forms. Very detailed step-by-step procedures are explained and illustrated in this chapter so students can quickly apply their new knowledge to novel problems. These steps can be used whether using traditional tools or freehand sketching. CAD concepts related to pictorial drawings are integrated into the chapter so students can apply the theory of axonometric and oblique drawings to CAD generated pictorials. There is a very extensive problem set preceded by a list of hints useful when creating a pictorial representation of an object.

Chapter 10, "Perspective Drawings," is an introduction to perspective projection and drawings. This chapter again builds on the information presented in Chapter 4, "Sketching and Text." Step-by-step instructions describe how to create one- and two-point perspective drawings. Extensive background material is provided so students understand the concepts underlying perspective projections. This basic understanding will be useful when creating perspective drawings using traditional tools, freehand sketching, or CAD.

Chapter 11, "Auxiliary Views," introduces the theory of auxiliary views and the techniques for drawing them. The fold-line and reference plane methods are explained using step-by-step instructions. Auxiliary view techniques are then applied to the solutions of problems concerning reverse construction, views in a specified direction, dihedral angles, and the true size of an oblique plane.

Part 3
Descriptive Geometry

Part 3 is a basic introduction to the theory and practice of descriptive geometry, intersections and developments.

Chapter 12, "Fundamentals of Descriptive Geometry," is an introduction to the application of descriptive geometry to the solution of spatial problems. There is extensive coverage of the underlying concepts and projection theory related to auxiliary views. This chapter serves as a solid foundation for descriptive geometry covered in this and the next chapters. One *unique* feature of this chapter is the five principles of descriptive geometry, which summarize the important concepts in the solution of spatial geometry problems. Another feature is the list of tips and axioms useful in solving such problems. The user is again provided an extensive problem set which can be used with traditional tools, sketching, or CAD.

Chapter 13, "Intersections and Developments," introduces two concepts: (1) the intersections between geometric forms and (2) 3-D geometric developments. The chapter presents the standards and techniques for drawing these important elements through detailed step-by-step illustrated procedures. One *unique* aspect of the illustrations used in the step-by-step procedures includes 3-D pictorial color illustrations of the intersecting objects, making it easier for the student to visualize the problem being solved.

Part 4
Standard Technical Graphics Practices

Part 4 includes six chapters which describe the standard practices commonly used to create technical drawings to support the engineering design process. In this part students learn how to create section views, dimension and tolerance a drawing, and represent fasteners on drawings. Modern manufacturing practices are covered as well as working drawings.

Chapter 14, "Section Views," is an introduction to the techniques and standards used to create all types of section views. One important concept is section view visualization, which is explained early in the chapter. Each section view type is examined in terms of its visualization, the applicable standards practices, and the techniques useful in its construction. A Summary of Important Practices is included at the end of this chapter to assist the student in making section views. Colors rendered in pictorial views of the objects in the section are used extensively in this chapter to assist students in visualizing the section technique being explained.

Chapter 15, "Dimensioning and Tolerancing Practices," introduces the techniques and standards for adding dimensions to technical drawings. There is extensive coverage of standard practices used for nearly any feature found on drawings, and they are explained using illustrations which sometimes include color rendered pictorial views useful in visualizing the dimensioning or tolerancing concept being explained. Numerous examples show how to dimension various geometric features. The need for tolerancing is discussed in great detail so that the student will understand and appreciate the importance of tolerancing in technical design. Step-by-step procedures are used to demonstrate the application of tolerances, as well as the use of ANSI standard fit tables. The summary includes two tables that condense important dimensioning and tolerancing information useful for students in developing their own technical drawings.

Chapter 16, "Geometric Dimensioning and Tolerancing Basics," introduces the standards, techniques, and practices associated with ASME Y14.5M-1994 standard geometric dimensioning and tolerancing. The chapter explains each type of geometric dimension, how it is measured, and how its associated symbols are used in technical drawings. There is extensive use of illustrations with rendered pictorial views of principle being explained.

Chapter 17, "Fastening Devices and Methods," introduces the student to various types of fasteners and their representation on technical drawings. Step-by-step procedures demonstrate how to read a thread table, create simplified and schematic internal and external thread forms, and draw bolts and springs. One *unique* feature of this chapter is the many references to the *Machinery Handbook* to familiarize students with this important guide to information on fasteners. Another is the very detailed explanation of how to read an ANSI standard thread table. The use of CAD to create fasteners is integrated into the chapter as well as important new concepts, such as Design for Assembly (DFA).

Chapter 18, "Integrated Production, Automation and Manufacturing Processes, and the Role of Technical Graphics," is an introduction to modern manufacturing and production processes. The chapter explains in contemporary terms the general manufacturing and production process and its relationship to technical design and drawing, including 3-D models. In addition, quality management, automation, and design for manufacturability (DFM) are explained. Some of the end-of-chapter drawing assignments are actual tooling devices used in manufacturing. This chapter has almost been entirely rewritten for the 3rd edition and includes many modern concepts and practices of manufacturing put into context for students learning engineering design graphics.

Chapter 19, "Working Drawings," describes how to create a standard set of drawings that specify the manufacture and assembly of a product based on its design. All of the important features of a set of working drawings are described and illustrated, along with engineering change orders (ECO) and reprographic practices, including digital technologies. There is a very extensive end of chapter problem set ranging from the very simple to the complex, useful for both individual and group assignments. The problem set has been updated with new problems in the 3rd edition including a mechanical pencil that can be purchased by the student and used as a reference for the drawing assignment.

Some of the assemblies used as problems in Chapter 19 are real parts that were purchased and reverse engineered using micrometers and other measuring instruments. 3-D CAD models were made from which the assemblies and pictorial detail drawings were created. To supplement lectures and labs students can order the parts for some of the assemblies from Reid Tool Supply Company, 2265 Black Creek Road, Muskegon, MI 49444-2684, phone 800-253-0421.

Figure 19.38 Quick Acting Hold-down Clamp
       Catalog Number KT-411
Figure 19.41 Screwless Vise
       Catalog Number GM-1
Figure 19.54 Kant Twist Clamp
       Catalog Number KT-410

Part 5
Technical Graphics in Industry

This part shows how graphics is used to support specific processes or industries, such as welding, piping, and gears and cams. The part includes a very detailed coverage of the engineering design process as used in industry.

Chapter 20, "Design in Industry," is an in-depth overview of modern engineering design practice in industry. Engineering design is explained in context with 3-D CAD modeling and the sharing of design information across the enterprise. Students learn how modern engineering design is practiced and the important role graphics and 3-D modeling play in this process. Design is explained as an integrated nonlinear process unlike other texts which approach it as a linear segmented process. The nonlinear approach more closely aligns with modern engineering design practice and aids the student's understanding and appreciation for the important role graphics play in design. The design process is covered in detail and includes important topics, such as ideation, the designer's

notebook, computer simulation, design analysis, and design review meetings.

Integrated within the chapter to aid students in learning design from an industry perspective are examples of the design process followed for the Motorola i1000 Handset Communicator. Numerous references are made to the Motorola handset in the chapter to place design topics into context of how real design is practiced in industry. In addition, an extensive and detailed Design in Industry box is located near the end of the chapter explaining how the Motorola handset was designed.

The chapter also covers a wide range of topics outside of the actual engineering design process. These other topics are important so students understand engineering design within the context of current industry practices. Engineering design is part of a much larger enterprise that must be understood by students. Students learn the role of marketing, finance, and management in the design process. Integrated throughout the chapter are references on the role of graphics and 3-D modeling in the design process.

The end of chapter includes an extensive listing of possible individual or group design problems that students can be assigned to practice design principles and document their design solutions using graphics. Included in this section are a number of reverse engineering problems that can be assigned to students. A section on problem solving activities is included which gives students experiences in solving problems to prepare for solving engineering related problems. This section includes information on finding engineering design case studies which students can study to better understand the engineering design process as practiced in industry. This section also includes an in-depth case study of the design and manufacture of the Boeing 777 passenger airliner.

Chapter 21, "Technical Data Presentation," describes how to create technical illustrations and represent data using both traditional techniques and computers. The chapter covers such modern illustration techniques as color theory, lighting, animation, and multimedia. Students learn the basic concepts used to represent data graphically followed by examples of charts and graphs produced from data. One *unique* feature of this chapter is the representation of 3-D graphs and charts to represent data.

Chapter 22, "Mechanisms: Gears, Cams, Bearings, and Linkages," is an introduction to the standard technical drawings for gears, cams, bearings, and linkages. In this chapter students learn the theory and practice used to represent mechanisms. Included in this chapter are a number of step-by-step procedures used to read mechanism catalogs and draw the mechanism using standard practices.

Chapter 23, "Electronic Drawings," is an introduction to the symbols and applications of electronic drawings in industry.

Chapter 24, "Piping Drawings," explains the fundamentals of piping, as well as the symbols used to create standard piping drawings.

Chapter 25, "Welding Drawings," is an introduction to welding processes and the symbols used to represent welded assemblies in technical drawings.

Glossary, 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.

The appendixes contain supplementary information useful to the student, such as an extensive listing of abbreviations commonly used in technical graphics; geometric dimensioning and tolerancing information; materials properties, useful when creating a materials library for CAD solid modelers; properties of geometric forms, useful for 3-D modeling; ANSI standard tolerancing tables; and standard fastener tables for drawing and specifying various fasteners, keys, washers, and pins.

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 can easily be found by the user.

The end pages of the text also include patterns of simple geometric forms. These patterns can be cut out by the student and formed into their 3-D shape. Instructors can use them to supplement their lectures, as visualization aids, and for additional problem assignments.

Supplements

A number of supplements have been developed to assist in the instruction of technical graphics. Most of these supplements are contained in the Graphics Instructional Library (GIL), which is available to those who adopt this text. The GIL contains the following items:

Instructor's Manual

This supplement is available in hard copy, on CD-ROM, or on the book's web site and it contains

Chapter objectives
Chapter outlines
Chapter summaries

Key terms
Questions for review with answers
True-false questions with answers
Multiple-choice questions with answers
Teaching tips and suggestions
Conversion notes for past Giesecke users

Solutions Manual

This solutions manual contains answers to the end-of-chapter word problems, as well as all of the end-of-chapter drawing problems. Solutions are available in hard copy, on CD-ROM, or on the web site.

Workbooks

Three traditional workbooks with additional problems are available. These three workbooks, *Problems for Engineering, Graphics Communication,* and *Technical Graphics Communication,* have been developed by the faculty at
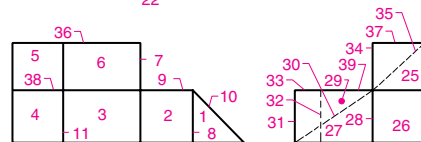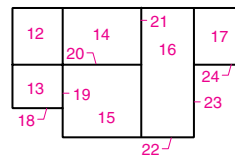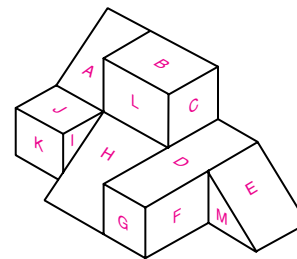
Surface	Top	Front	Side
A			
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Purdue University and have been subjected to more than 30 years of classroom testing. In addition, another workbook, *Graphics Drawing Workbook,* contains many of the problems found in the text in workbook form. This workbook has many traditional and nontraditional types of problems that are useful for visualization exercises and 3-D modeling. All workbook problems have been solved and are available to the instructor for reference and grading.

CAD Workbooks

CAD workbooks are available that can be used to supplement the theory and practice found in the text. CAD books have been written for Pro Engineer, AutoCAD, Mechanical Desktop, and CADKEY software.

Online Learning Center (OLC)

The OLC Website follows the textbook chapter by chapter. As students study, they can refer to the OLC Website for learning objectives, a chapter summary, video, an interactive 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 the address. Before taking an exam, students will know if they're ready thanks to interactive exercises and taking self-grading quizzes.

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

Most importantly, the OLC Website serves as a doorway to other McGraw-Hill Solutions like PageOut and Power-Web—both of which are free to McGraw-Hill adopters.

PageOut

PageOut® is exclusive technology by McGraw-Hill that can be used by instructors to create web sites for their courses. No prior knowledge of HTML is required, no long hours of coding, and no design skills are necessary on your part!

Instead, PageOut® offers a series of templates. Simply fill them with your course information and select one of the many designs. This process takes very little time and leaves you with a **professionally designed web site.**

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. (Many of these terms need to be linked to the relevant illustration in the text)

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

Graphics in Motion   A few chapters include QuickTime VR files that can be downloaded and played on a computer. These files are 3-D models of problems found at the end of the chapter. The student can play and control the movie to better visualize and understand the 3-D form of the problem represented in 2-D in the textbook.

Web Site Links   Many chapters include numerous web site 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.
- Booleans—animation concepts of union, difference, intersection, and composite solids.
- Multiviews—animation showing the concept of multiviews via a glass box surrounding an object.

- Right-hand rule—animation showing "finger" relationship to axes and positive rotation concepts.
- Glass box—animation showing the glass box projection concept.
- Solid modeling—animation showing examples of solid modeling.
- Surface modeling—animation showing examples of surface modeling.
- World and local coordinates—world and local coordinate concepts
- Wireframe modeling—animation showing concepts of wireframe modeling.
- 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.

AutoCAD Starter Files   Some chapters contain AutoCAD files of the end of chapter drawing problems that can be used by students. Starter files are useful if using a template to grade student work.

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

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Illustrators

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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 grbertol@tech.purdue.edu.

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