Technical Drawing for Engineering Communication

Seventh Edition

INSTRUCTOR'S RESOURCE GUIDE

David L. Goetsch
Raymond L. Rickman

CENGAGE Learning®

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

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INTRODUCTION

To help teachers present the content of *Technical Drawing for Engineering Communication, 7E,* we have provided General Information on how to use the text and supplements. Lesson Plans are provided in Section 2. Solutions are provided to all Drawing Problems and answers are provided to all Review Questions. As a result, this *Instructor's Resource Guide* should be a valuable tool for teachers of technical drawing.

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GENERAL INFORMATION

A. Suggestions for Effective Use of the Text and Instructor's Resource Guide

1. **Review of Chapter**

   A practice test of true/false and multiple choice is included in the text following each chapter. These may be used for class discussion; to ensure that students read the assigned material; as make-up work for students who miss class; or in any other manner that the instructor desires. The answers to all practice test questions are found in the text. No outside reading is required.

2. **Student Projects**

   Included at the end of each chapter are design and drawing projects that will aid the student in applying the concepts presented in the chapter. Icons next to each project indicate the drafting discipline (mechanical, architectural, etc.) of the project.

3. **Lesson Plans**

   The lesson plans for each chapter that are included in this guide have the following format: (1) goal for the chapter, and (2) suggested topics for discussion. The goal represents the desired student learning stated in broad terms. Specific objectives for each chapter are found in the text at the beginning of the chapter. The suggested topics for discussion follow the same order as the text material and are presented as a brief outline of the major parts of the chapters. Since instructor preferences vary, actual teaching approaches are left to the discretion of the individual instructor.

4. **Chapter Tests**

   The next section of this guide consists of objective drawing tests. These may be used for pre- and post-testing if the instructor so desires. The solutions to the tests are grouped together and appear in the section following the tests.

B. Equipment and Supplies for Teaching Drafting and Design

General Instructional Equipment (in department or available for department use)

- Overhead projector
- Marking pens in several colors and acetate overlay
- Cassette tape recorder
- Video cassette recorder (VCR)
- VCR or DVD player
- Computer with printer, plotter, and CAD software
- PowerPoint® projector and laptop computer

C. Design and Drafting Association

American Design and Drafting Association
P.O. Box 799
Rockville, MD 20848-0799
(301) 460-6875
http://www.ADDA.org

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LESSON PLANS

Introduction Graphic Communication and Technical Drawing

Goal

The goal of this chapter is to provide students a foundational overview of graphic communication and technical drawing.

Discussion Topics

1. Discuss the concept of graphic communication.
2. Discuss the different types of technical drawings.
3. Discuss the different applications of technical drawings.
4. Discuss the role of design and drafting in promoting quality and competitiveness.

Objectives

After studying this chapter you should be able to:

1. Explain the concept of graphic communication.
2. Define the term *drawing*.
3. Differentiate between artistic and technical drawings.
4. List and explain the types of technical drawings.
5. Explain the purpose of technical drawings.
6. Explain the different applications of technical drawings.
7. Explain the concept of regulation of technical drawings.
8. Describe the role of design and drafting in promoting quality and competitiveness.

Teaching Hints

This chapter explores the various methods of graphic communication. Begin by having students brainstorm for as many examples of graphic communication as possible. Then categorize these examples into the three main types of graphic communication: artistic drawings, technical drawings, and illustrations. To reinforce this information, have students find examples of these types of graphic communication in magazines. Types of technical drawings should be presented to students with the teacher providing examples of each.

The design process is a key element in becoming a competent draftsperson. Students should be able to do more than complete a drawing using drafting tools or a CAD system. They must also be able to creatively solve technical problems and transfer the solution to paper. Therefore, while discussing the design process, include numerous examples for each step and relate the importance of each step. You may wish to solve a design problem corporately with your students to reinforce these steps. Various design problems are supplied throughout the book.

For the remainder of the chapter, students should be able to see the illustrations and relate the content. Pay particular attention to the section on quality and competitiveness. Students must realize that drafting is no place for sloppy or mediocre work. The profession demands quality work and neat drawings, regardless if drafting tools or a CAD system is being used.

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Chapter 1 Employability Skills for Drafting and Design Technicians

Goal

The goal of this chapter is to teach students how to develop the employability skills needed to secure good jobs in their field and succeed in those jobs.

Discussion Topics

1. Discuss the definition of employability skills.

2. Ask students for examples where 'soft' skills have helped them accomplish a goal.

3. Ask the students, in groups or individually, to select one entry from the "Categories of Employability Skills" (Figure 1-4) on page 22 that they feel is most important. Have an open discussion and weigh the answers as a class.

4. Discuss the job seeking skills needed by drafting and design technicians and how they may be acquired and maintained.

5. Discuss how required employability skills have changed over the years, and how they may continue to change in the future.

Chapter Objectives

Upon completion of this chapter, students should be able to do the following:

- Define the term *employability skills.*
- Explain the importance of employability skills to drafting and design technicians.
- List the most important employability skills for drafting and design technicians.
- Demonstrate the skills necessary to secure employment in drafting and design.

Teaching Hints

As future CAD operators, students should understand the basic components and functions of a computer system. Explain to students that they will need this information when upgrading, installing software, replacing peripheral devices, and troubleshooting problems. This will become even more essential as computers become more complicated and integrated. Students may access excellent internet web sites to learn about computer systems, but should also be taught how to evaluate resources before adopting them. Books, magazine articles, and videos will also enhance this chapter.

Begin by explaining the outward components of a computer system. Explain how these devices are connected to the central processing unit and a network if applicable. Using an old or damaged computer system, remove the cover from the CPU and identify the internal components for the class. Set up this computer so students can examine it in pairs or trios. Consider designing a worksheet for the groups to complete as they identify and explain the computer parts. Give students a computer magazine to list components that would fit into the computer system, because they should understand the cost of the computer components. If possible, allow students to view older magazines to compare how prices have changed over the past few years.

The best way to teach students about the internet is to have them actually use it. The computer on campus should be able to set up internet and email accounts for the students. Have the students send email messages to each other. You could use email to simulate two CAD operators working on the same drawing, but in different locations. When using the internet, provide students with a directed task. They should have step-by-step instructions to follow that allow them to visit a variety for computer and CAD sites.

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Chapter 2 Drafting Tools: Conventional, CAD, and Solid Modeling

Goal

The goal of this chapter is to teach students how to: 1) use the most common conventional drafting tools; 2) explain the concepts of CAD and solid modeling.

Discussion Topics

1. Discuss the most frequently used conventional drafting tools and the methods/tools that replaced them.
2. Discuss the concept of computer-aided drafting (CAD).
3. Discuss the most important features of CAD Software and compare opinions.
4. Discuss the concept and history of solid modeling.
5. Discuss the impact of consumer-based 3D printing on the direction of the industry.

Chapter Objectives

After studying this chapter you should be able to:

1. Recognize the most frequently used conventional drafting tools.
2. Demonstrate the proper use of the most frequently used conventional drafting tools.
3. Explain the concept of computer-aided drafting (CAD).
4. Explain the most important features of CAD software.
5. Explain the concept of solid modeling.

Teaching Hints

The field of drafting and design has come a long way since the advent of personal computers with the power to run sophisticated CAD software and with advances in the concept of solid modeling and 3D printing. Although students are going to learn drafting and design using CAD and solid modeling, there is still value in them learning to use selected conventional drafting and design tools. It is helpful to require things be done manually and use that competency as 'license' to use the far easier technology-based tools. Some of the concepts that are fundamental to drafting and design and engineering communication can still be taught more effectively suing these conventional instruments.

Begin the lesson by discussing how some conventional drafting equipment is still important and may be used in conjunction with CAD and how many of the CAD commands are based on the operation of certain items of conventional drafting equipment. For instance, in CAD, circles can be drawn from a given center point, the same way a compass and circle templates operate. During the lesson, discuss with the students how a drafting tool corresponds to similar CAD commands.

Another option for students to learn how the tools operate is to give each of them two or three tools for practice use. As you monitor their progress they should write a brief description of the tool, how it operates, and its purpose. The students can then teach the rest of the class about their particular tool. Finally, as students work on drawings with drafting tools, ask them individually about the tool they are using and why they chose it. This will reinforce what they have learned and give you an opportunity to check their understanding. Once students have a grasp of how these selected conventional tools are used, move on to CAD and teach them how the conventional tools evolved into CAD and solid modeling.

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Chapter 3 Sketching and Lettering for Engineering Communication

Goal

The goal of this chapter is to teach students how to develop skills in lettering and sketching.

Discussion Topics

1. Explain the concept of talking sketching.
2. Discuss the various styles of freehand lettering and good lettering characteristics.
3. Discuss the various types of lines used on technical drawings.
4. Discuss the four styles of sketches. Which is best, when?
5. Discuss the materials needed to make sketches.
6. Discuss the most commonly used sketching techniques.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the concept of talking sketching including the two kinds.
2. List the various styles of freehand lettering and the characteristics of good lettering.
3. Explain the techniques one must know in order to do freehand lettering.
4. Illustrate the various types of lines used on technical drawings.
5. Illustrate the four types of sketches.
6. Explain what materials are needed in order to make sketches.
7. Demonstrate the most commonly used sketching techniques.

Teaching Hints

Begin this chapter by discussing the advantages and disadvantages of sketching. Students should see that sketching is a part of the design process and essential for those who want to communicate ideas quickly. Pass out a napkin, a scrap piece of paper, or a piece of notebook paper to each student. Put the students into pairs and give them the name of a fictitious product that they are to design by sketching on the provided medium. Because they are in pairs, students should discuss the elements of the product and how it should function and look.

When discussing lettering, students should understand why proper lettering is essential to quality sketches. Although precise and neat lettering can be done using a CAD system, the skill of lettering is still important since much of the communication between engineers and drafting and design technicians involves sketching and lettering. Distinguish between lettering and writing. The PowerPoint slide presentation illustrates the differences between the font and style of letters. Finally, discuss with the class the five characteristics of good lettering technique: neatness, uniformity, stability, proper spacing, and speed. These are described in the PowerPoint slide presentation.

The final section of the chapter covers sketching in more detail. Students primarily learn how to draw various types of projections using graph paper. Demonstrate this skill by showing small groups of students at a time. The proper sketching technique cannot be seen as well on the chalkboard in front of the entire class. When demonstrating the aspects of sketching, explain the principles of proportion and the differences between the types of projections.

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Chapter 4 Geometric Construction

Goal

The goal of this chapter is to teach students how to develop technical drawings using geometric construction.

Discussion Topics

1. Quiz students on geometric nomenclature and terms.
2. Recite the steps required to perform basic constructions.
3. Recite the steps required to perform polygon constructions.
4. Describe the six types of polygons.

Chapter Objectives

After studying this chapter you should be able to:

1. Define the most frequently used terms in geometric nomenclature.
2. Properly apply the elemental principles of geometric construction.
3. Demonstrate the proper procedures for polygon construction.
4. Demonstrate the proper procedures for circular construction.
5. Demonstrate the proper procedures for supplementary construction including the following: spiral; helix; involute of a line, triangle, square, and circle; and cycloidal curve.

Teaching Hints

Students need to develop a working definition of the terms in the chapter to fully understand and implement geometric construction. A working definition includes a written and a drawn example, plus it describes the subject item's use in everyday life. The terms and a written definition have been provided in the PowerPoint slide presentation. As you proceed through each term, be sure to draw an example of each on the board. Students then should be able to identify where they have seen the shapes being used in everyday life.

If students understand the basic concepts of constructing geometric shapes using drafting tools, then they will make an easier transition to the fundamentals of CAD. It may not be necessary to work through every shape detailed in the chapter as a class. Many of the directions have been summarized in the PowerPoint slide presentation. These can be projected onto a screen and drawn at the same time. Some of the problems should be given to the student to follow the directions and solve individually. Have the students check their work by writing an explanation of why they did each particular step. Although they may find this exercise tedious, when they need to reference their work later it will be easier to remember the procedures.

Finally, demonstrate to the student how to draw some of the common shapes (circle, square, ellipse, octagon, tangent arcs and lines, triangles, and lines) detailed in the chapter using CAD. To improve their CAD skills, you could also have the students follow the directions given in the chapter to draw the shapes using CAD as if it were a drafting tool. In other words, when they are to draw a tangent arc between two lines, students should draw the arcs parallel to each line, attach tangential lines, and then draw the resulting arc from the line intersection. This will show them that the same techniques are possible with CAD, and sometimes absolutely necessary.

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Chapter 5 Spatial Visualization and Multiview Drawings

Goal

The goal of this chapter is to teach students the fundamentals of technical drawing through use of multiview drawings.

Discussion Topics

1. Compare 2D and 3D spatial visualization.
2. Discuss the prevalent orthographic projection techniques and their best use.
3. Discuss the five steps required in planning the development of a typical drawing.
4. Discuss the need for and use of technical drawing conventions.
5. Discuss the difference between first-angle and third-angle projections.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the concept of spatial visualization.
2. Demonstrate proficiency in the use of spatial visualization.
3. Demonstrate proficiency in the use of orthographic projection.
4. Demonstrate proficiency in all five steps of planning a drawing.
5. Demonstrate proficiency in centering a drawing.
6. Demonstrate proficiency in making proper use of technical drawing conventions.
7. Demonstrate proficiency in applying visualization techniques.
8. Explain the difference between third- and first-angle projections.

Teaching Hints

Teaching future CAD technicians the fundamentals of multiview projections is the same as teaching algebra students how to add, subtract, multiply, and divide before allowing them to use calculators. Because most engineering drawings are represented by multiview projections, this content is critical to the successful use of drafting and CAD. Use a simple wood or metal object that has a hole and beveled edge and a clear plastic box that will cover it. Set the object on a desk and place the box over it. Show students that observing the object when the observer is perpendicular to one side of the box represents each view. Have students sketch what they believe to be the front view. Now draw the front side on the chalkboard. Discuss with the class why it is drawn as portrayed on the board. Proceed likewise in drawing the remaining views as outlined in the chapter. Be sure to explain and demonstrate how to transfer distances between views using fold lines, the 45-degree projection line, or dividers. The spacing between views will become critical when students are required to dimension their drawings, so make sure they understand that at this point.

Realize that some students will have a difficult time understanding the basics of spatial visualization. Reinforce that with practice this can be overcome. One technique is to have students visualize an object in their mind or hold an object in their hand and then rotate it to view a different side or feature. What they see when looking straight at the object is what they draw. Students also must understand why the views are placed in their respective locations. Again, use the clear box, but this time use a strong tape to adhere the edges together. Label one side as “front” and have the class label the remaining sides. Then unfold the box and show the location relationship between the views.

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Chapter 6 Dimensioning and Notation

Goal

The goal of this chapter is to teach students how to be proficient in the use of dimensioning and notation in technical drawing.

Discussion Topics

1. Compare and contrast the three main dimensioning systems used in the United States.

2. State the steps used in laying out dimensions for an object.

3. Discuss the concept of 'group technology' as it relates to design and drafting.

4. Describe the components that are common to all dimensioning systems.

5. Discuss the need for and proper application of notation.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the three main dimensioning systems used in the United States: metric, decimal inch, and fractional dimensioning.

2. Demonstrate proficiency in properly using the following dimension components: extrusion lines, dimension lines, leader lines, and arrowheads.

3. Demonstrate the steps used in laying out dimensions for an object.

4. Demonstrate proper application of the dimensioning techniques for the following: dimensioning symbols; dimensioning chords, arcs, angles, radii, curved surfaces, offsets, irregular curves, contours, multiple radii, normal objects by offset, spheres, and round holes; making simple hole callouts; applying drill size tolerances; dimensioning hole locations for single and multiple holes; and locating holes about a bolt center.

5. Demonstrate proficiency in applying the following dimensioning techniques: locating holes on center lines and concentric arcs; multiple holes along the same center line; repetitive features; callouts for tapered holes; callouts for countersunk holes; callouts for counterbored holes; dimensioning a cylinder and a square; double dimensioning; reference dimensioning; dimensioning slots and rounded ends; not to scale dimensions; nominal dimensions; dimensioning external chambers, internal chambers, necks, undercuts, knurls, and keyways; staggered dimensions; and dimensioning flat tapers, round tapers, threads, pads, bosses, sheet metal bends, sectional views, pyramids, and cones.

6. Demonstrate proficiency in applying the following dimensioning techniques: dimensioning concentric and non-concentric shafts, rectangular coordinate dimensioning, dimensioning holes on a bolt center diameter, finish marks, X-Y-Z coordinates, tabular dimensioning, tabular drawing, tolerancing, shaft limits, hole limits, allowance, clearance, interference fit, transition fit, size limits, design size, maximum and minimum sizes, location limits, design location, maximum and minimum location, calculating fits, matching parts, and standard fits.

7. Demonstrate proficiency in the proper application of notation.

8. Explain the concept of group technology as it relates to design, drafting, and CAD.

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Teaching Hints

The first step in teaching this chapter will be to present the standards students must meet when dimensioning in English or metric units. They must be made to realize that dimensioning is based on a set of industry standards that are followed. These standards are meant to provide consistency between drawings regardless of the engineering or CAD firm, employee, or location. This will lead into a discussion and examples from the PowerPoint slide presentation regarding the dimension systems that are commonly used. Now explain the basic parts of the dimension unit (i.e., extension lines, dimension lines, leader lines, and arrowheads).

Because of the many aspects of dimensioning presented in the textbook, explain that the chapter will primarily be used as a reference section. Use the PowerPoint slide presentation to illustrate and demonstrate basic dimensioning practices. Students should memorize these practices because they are the ones most commonly used. The others should be referenced in the textbook chapter. In pairs, have the students add dimensions to several drawings from the workbook by using the textbook as a reference source. They should complete only one drawing and continuously check each other's work. One person can be designated as the "researcher" and look in the textbook chapter while the other person is the "CAD technician." If the students have purchased the textbook, encourage them to create page tabs and mark the most commonly used dimensioning practices.

A similar procedure can be used to demonstrate dimensioning using a CAD system. In pairs or individually, assign students a drawing to dimension from the CAD disk. Explain to students that unlike hand-drawn dimensions, CAD drawings can be dimensioned in any order because the dimensions can be easily moved or changed. Demonstrate how to change the features of a dimension unit such as the text size, text style, arrowhead, angle, rotation, color, and style.

To help students understand the concept of group technology, allow them to conduct an internet search for the related terminology and then determine how it may impact them. If there are local industries that incorporate group technology, invite one of their managers in that department to speak to the class and discuss the concepts.

Chapter 7 Sectional Views

Goal

The goal of this chapter is to teach students how to correctly draw the details of an object using a sectional view or cross section.

Discussion Topics

1. Define and describe a sectional view, including when one is needed.
2. Discuss what is meant by a "cutting plane."
3. Define and describe aligned sectioning, including when it is advised.
4. Compare the different types of sections.

Chapter Objectives

After studying this chapter you should be able to:

1. Describe the concept of a sectional view.
2. Define the term *cutting plane*.
3. Illustrate section lining.
4. Prepare the following kinds of sections: full, offset, half, broken-out, revolved, removed, auxiliary, thinwall, and assembly.

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5. Demonstrate how to create the following in sections: ribs, webs, holes, spokes, fasteners, shafts, and keyways.

6. Explain aligned sectioning.

7. Show intersections in sections.

Teaching Hints

The most difficult aspect for students to understand about creating sectional drawings is visualizing what an object looks like inside. Having just completed multiview drawings in Chapter 5, there may be a tendency to simply redraw one of the views and add section lines. Locate an object such as a small gas engine piston or a picture frame with a profiled edge. A wooden or Styrofoam block could also be cut into a shape similar to those shown in the drawing problems section of this chapter. The object should then be cut with a saw to represent a sectioned view drawing. This can then be used to demonstrate to the class what a section view looks like as compared to a multiview drawing.

A discovery learning approach can also be used with the concept of sectional views. While holding a simply shaped object, ask the class, "What will we see if we cut this object in half?" Draw this on the board for the class. Then lead the class in a discussion regarding how to represent the areas in which the saw that cut the object did and did not come in contact. What if the material is made of brass instead of steel, how would it be shown? Now present section lining for various materials. Follow the same procedure for a half section, removed section, and revolved section. Show the class other objects and have them sketch examples of each type of section. List on the board the characteristics of each type of section and show the PowerPoint slide presentation about this chapter. Finally, spend time discussing when to use and when not to use a section view. Be sure that students do not create a section view when a normal multiview will suffice.

Chapter 8 Auxiliary Views

Goal

The goal of this chapter is to teach students how to draw the surfaces of an object using an auxiliary view, and under what circumstances an auxiliary view is necessary.

Discussion Topics

1. Discuss the three purposes that an auxiliary view serves.

2. Discuss the advantages of an auxiliary view.

3. Define and describe a secondary auxiliary view.

4. Define and describe a partial auxiliary view.

5. Define and describe an auxiliary section.

6. Discuss when a half auxiliary view is used.

Chapter Objectives

After studying this chapter you should be able to:

1. Define the concept of an auxiliary view and list its advantages.

2. Describe and use the reference plane method to draw an auxiliary view.

3. Describe and use the folding line method to draw an auxiliary view.

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4. Draw round and curved surfaces in auxiliary views.

5. Illustrate secondary auxiliary views.

6. Illustrate partial auxiliary views.

7. Draw enlarged auxiliary views.

8. Describe the use of a viewing plane for auxiliary views.

Teaching Hints

Show the class an orthographic projection of an object that requires an auxiliary view to be drawn. Allow them time to discuss and develop ways to show the surface as true shape. It may be necessary at this time to review the definitions of true shape, true length, and foreshortened. Provide plenty of examples, as these are the foundational requirements of understanding auxiliary views. Write the students' ideas on the board and discuss the advantages and disadvantages of each method proposed. This procedure will get the students to think about why certain procedures are used in drafting and CAD rather than just reading and practicing it.

Emphasize to students that they should be able to recognize when an auxiliary view is needed and the purpose it serves. Relate this chapter to the section in Chapter 5 regarding multiview drawings, because an auxiliary view is actually another view seen from outside the glass box. The difference is that this time the box has a seventh or eighth side and it is parallel to the oblique surface. Students should see that important dimensional data cannot be obtained from oblique surfaces, because the true shape and size is not given on the multiview projection.

If possible, cut a wooden model or fold a paper model of the object referenced at the beginning of these teaching hints. Discuss with the students that the size of an attaching piece cannot be derived from the multiview projection. Demonstrate how to draw the primary and secondary auxiliary views on the board for the class to see. Have the students write definitions of the words that are listed at the beginning of the chapter. Finally, demonstrate on the computer how to use the perpendicular command so that projection lines can easily be drawn from the reference lines.

Chapter 9 Descriptive Geometry

Goal

The goal of this chapter is to teach students how to apply descriptive geometry to various drafting and CAD problems.

Discussion Topics

1. Discuss the reasons for using the descriptive geometry method of projection.

2. Discuss the basic steps used to solve descriptive geometry problems.

3. Discuss the term *fold line*.

4. Describe the process used to determine the true length of a line.

5. Compare the two methods used for calling out a bearing.

6. Discuss the concepts of cut and fill.

7. Discuss the concepts of strike and dip.

8. Discuss the use of vectors.

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Chapter Objectives

After studying this chapter you should be able to:

1. Explain the reasons for using the descriptive geometry method of projection.
2. List the steps used to solve descriptive geometry problems.
3. Demonstrate proficiency in the use of the system of notations.
4. Define the term *fold line*.
5. Demonstrate proficiency at using fold lines.
6. Demonstrate proficiency in determining the position of a line in space by using its bearing, slope, and grade.
7. Demonstrate proficiency in plotting the boundaries of real estate.
8. Demonstrate proficiency in applying the concepts of cut and fill.
9. Demonstrate proficiency in applying the concepts of strike and dip.
10. Demonstrate proficiency in the use of vectors.

Teaching Hints

This chapter can be the most difficult aspect of drafting and CAD for many students. Simply seeing the word *geometry* convinces some that because they are not good at mathematics they will not do well with this material. Therefore, begin this chapter by giving some real-life examples of why this content is important. At the end of the chapter, note the excellent examples such as surveys, contour lines, bridge trusses, roof trusses, and force diagrams. Students must realize that all of the principles of descriptive geometry are mathematically based, but most of them do not require an advanced knowledge of mathematics.

Review the basic principles of auxiliary projections and why such drawings are needed. Remind students that lines and surfaces will be foreshortened if they are not parallel to a viewing plane, but that a viewing plane can be added at convenient places to view them as true shape and size. This is basically the technique used for auxiliary views and is the same for descriptive geometry.

Using the PowerPoint slide presentation, go through the steps to find the true length of a line, point view of a line, edge view of a surface, and dihedral angle of two lines. In addition to the steps, note the diagram that shows the steps together. Consider having the students write down the steps and then apply them as they view the diagram. Discuss these with the entire class. It is also critical to ensure that the students know *why* the steps are done—not simply *how* to do them. If students cannot grasp the fundamentals of line geometry, the remainder of the chapter will become more of a challenge.

To explain surface intersections, cut out two triangles of different colors from card stock or cardboard. In one of them, cut a slit for the other to fit into. Use this to introduce the concept of surface intersections. While holding the two intersected pieces of paper, tilt them away from the class so they can see that sometimes planes are neither parallel nor perpendicular to a principal viewing plane. Use the same technique with the PowerPoint slide presentations for plane intersections as was used when discussing line geometry. Demonstrate surface intersections and line geometry using a 3-D CAD program if possible. Draw two surfaces that intersect and revolve to see how the lines become foreshortened and sometimes distorted.

For the section about bearing, slope, and grade, have students divide an $11'' \times 17''$ sheet of paper into six equal blocks. As you proceed through the PowerPoint slide presentation, ask students to draw an example of each and write a short explanation. Some students may have a difficult time understanding the relationship of headings such as the directions of north, south, east, and west. Review the basic principles of directions and map reading if necessary. Finally, give plenty of verbal and illustrated examples of each of the methods used to indicate the inclination of a line.

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The final section may be left to advanced students. This material provides excellent examples of when descriptive geometry is needed in the real-life applications. Be sure to review some of the basic concepts of each of the topics, but an in-depth study may not be necessary for every student. These topics will be covered in later, more advanced courses in drafting and CAD.

Chapter 10 Patterns and Developments

Goal

The goal of this chapter is to teach students how to use patterns and developments in technical drawings and CAD.

Discussion Topics

1. Compare the three major kinds of surface developments.
2. Compare the two major types of notches.
3. Compare the two basic kinds of charts used to calculate bend allowance.
4. Describe the construction of a true-length diagram.

Chapter Objectives

After studying this chapter you should be able to:

1. Define the term *development* and list the major kinds of developments.
2. Demonstrate proficiency in making parallel line developments.
3. Demonstrate proficiency in making radial line developments.
4. Demonstrate proficiency in the application of triangulation developments.
5. Demonstrate proficiency in constructing a true-length diagram.
6. Explain when and how the two major types of notches are used.
7. Demonstrate proficiency in performing bend calculations.

Teaching Hints

Prior to this lesson, have students bring in an example of something that requires a pattern development such as a French fry container, soup can, envelope, folder, paper bag, book cover, or plastic case. Unfold the items that can easily be unglued and safely opened. Discuss with the class what each of these items has in common. They should recognize that they have tabs, a common stretchout line, fold lines, and precise design.

Introduce each of the three types of developments by using the PowerPoint slide presentation, where they are described and the steps used to construct each are given. Students should copy these into their notes and sketch examples. Stress the importance of drawing the developments accurately. You may want to create a box that has fold lines that are not parallel and try to fold it together. This will show the class that even if one fold line is skewed, the object will not fold correctly. Have the students complete the CAD exercises. When they have done so, make a photocopy of them and have students fold them to see if they work correctly. To create a clean fold, have students use a medium ballpoint pen to draw over the lines that require folding.

To conclude the chapter, students should be given a chance to cut one of their pattern developments from sheet metal or card stock. Before they begin drawing the pattern on the metal or card stock, discuss

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the importance of factoring in the amount of material it takes for a corner to fold. Use the Appendix in the textbook in conjunction with the PowerPoint slide presentation to show students how to determine the bending allowance. Some students may need to redraw their pattern development to factor in the bend allowance. Finally, students should present their final product to the class and consider the cost to produce one, the percent of waste, and any other items that you determine.

Chapter 11 Solid/3D Modeling: Computational Design and Analysis

Goal

The goal of this chapter is to teach students the advantages of visualization and the various categories of engineering visualization.

Discussion Topics

1. Compare and contrast the three types of 3D modeling: wire frame modeling, surface modeling, and solid modeling.

2. Discuss how Boolean operators are used in solid modeling applications.

3. Survey the types of visualization images that the power of today's computational technology has made available: still images, transparency, photorealism, animation, stereo images, holography, and virtual reality.

4. State the importance of visualization in the design process.

5. Discuss the concepts of finite element analysis, thermal analysis, and computational fluid dynamics.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the advantages and disadvantages of using visualization.

2. Describe the most widely used 3D imaging techniques.

3. Describe the Boolean operators used to generate solid models.

4. Explain the various methods used to represent variables.

5. Explain the various categories of engineering visualization.

Teaching Hints

This chapter is unlike the first ten chapters of this book in that no specific CAD, drafting, or design skills are introduced. Rather, students learn the basic principles of visualization and transfer that information into their experiences with design and CAD. Discuss the information in the PowerPoint slide presentation and be sure to provide many examples. It is also important to give specific advantages and disadvantages of each type of visualization image.

Have students find pictures that exemplify the types of visualizations by searching in magazines, other textbooks, or on the internet. They should not only be able to identify the type of visualization, but also why that type was chosen of that particular application. Students should then pick their most unique picture and present it to the class.

Finally, demonstrate to the class how a solid modeling computer program functions by drawing various 3D objects. This is also a good way to distinguish between wire frame, solid modeling, and surface modeling.

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Chapter 12 Geometric Dimensioning and Tolerancing

Goal

The goal of this chapter is to teach students how to develop skills in geometric dimensioning and tolerancing.

Discussion Topics

1. Discuss the concept of geometric and positional tolerancing.
2. Compare the different types of tolerances.
3. Discuss the purpose of a modifier.
4. Discuss the concept of least material condition (LMC).
5. Discuss the concept of maximum material condition (MMC).
6. Discuss the concept of regardless of feature size (RFS).
7. Discuss what is meant by projected tolerance zone.
8. Discuss the concept of positioning.

Chapter Objectives

After studying this chapter you should be able to:

1. Describe what is meant by the term *general tolerancing*.
2. Define the concept of geometric dimensioning and tolerancing (GD&T).
3. Explain the purpose of a modifier.
4. Distinguish between the concepts maximum material condition (MMC) and regardless of feature size (RFS).
5. Explain the concept of least material condition (LMC).
6. Describe what is meant by projected tolerance zone.
7. Make a sketch that illustrates the concept of datums.
8. Demonstrate how to establish datums.
9. Apply feature control symbols when dimensioning objects.
10. Explain the concept of true position.

Teaching Hints

In this chapter, divide the different feature control symbols among the students. Each student should be responsible to review one symbol, create a drawing, and present the symbol to the class. Students will become experts at one of the feature control symbols. Once students begin creating drawings using geometric dimensioning and tolerancing (GD&T), they will be able to refer their questions to the student in the class who is a particular expert of that symbol.

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Show the PowerPoint presentation to the class. Students should take notes on each of the symbols and write a brief description of how each is used. It is also important that students make sketches to help them remember how particular symbols are used. Make sure to relate the GD&T principles to the dimensioning principles discussed in Chapter 6.

Finally, students should be able to not only correctly dimension and add tolerance notations, but also distinguish between when each of the symbols is appropriate in the manufacturing process. Show the class a set of drawings that a local industry might use for such an example and compare the drawings to an actual object. By doing this, students should see the practical applications of GD&T.

Chapter 13 Fasteners

Goal

The goal of this chapter is to teach students the different kinds of fasteners that can be used in technical drawings, and how to draw them.

Discussion Topics

1. Compare the different classifications of fasteners.
2. Discuss the four applications of threads.
3. Describe the tap and die processes.
4. Compare and contrast screws, bolts, and studs.
5. Discuss how to distinguish between right-hand and left-hand threads.
6. Discuss the concept of thread relief.
7. Discuss the uses of keys and keyseats.
8. Discuss the concept of fastening systems.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the classifications of fasteners.
2. Explain the four uses of threads.
3. List the various screw thread forms.
4. Distinguish between the tap and die processes.
5. Demonstrate two methods for measuring threads per inch.
6. Define the term *pitch*.
7. Distinguish between single and multiple threads.
8. Demonstrate how to distinguish between right- and left-hand threads.
9. Demonstrate the various methods of thread representation.
10. Explain the concept of thread relief.

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11. Distinguish among the following: screw, bolt, and stud.

12. Demonstrate the proper methods for drawing screws, bolts, and studs.

13. Define the term *rivet.*

14. Explain the concept of keys and keyseats.

15. Explain how grooved fasteners are used.

16. Describe the uses of spring pins.

17. Explain the concept of fastening systems.

18. Describe how retaining rings are used.

Teaching Hints

Begin this activity by passing out a simple product such as an electric can opener, motor, or electric fan. Have students take these items apart and examine the types of fasteners that are used in each product. Most students will not realize the extent to which fasteners are used and the variety of fasteners that are incorporated into the machine.

Show the PowerPoint slide presentation to the class. It is important that students recognize how threaded items function. Pass out a variety of bolts, screws, and nuts so students can examine them and discuss the thread properties. This will correspond to the PowerPoint slide presentation information. After the thread portion of the lesson, have the students draw a schematic and simplified version of the same bolt.

For the remainder of the chapter, students should finish viewing the PowerPoint slide presentation and take appropriate notes. Reference the illustrations and especially the tables in the text. It is extremely important that students can read a table such as the one referring to grooved pins or rings. CAD problems will supplement the remainder of the content in the chapter.

Chapter 14 Springs

Goal

The goal of this chapter is to teach students how to develop the skills needed to design and construct special springs.

Discussion Topics

1. Discuss the classifications of springs.

2. Compare the three different kinds of helical springs.

3. Discuss the various terms associated with springs and their designs.

4. Discuss the data that should be included as part of a spring drawing.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the classifications of springs.

2. Describe the three different kinds of helical springs and their functions.

3. Define the function of flat springs.

4. Define the various terms associated with springs and their design.

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5. List the spring data that should accompany spring drawings.

6. Demonstrate proficiency in drawing the various types of springs.

7. Demonstrate proficiency in applying standard CAD practices when drawing springs.

8. Demonstrate proficiency in drawing sectional views of springs.

9. Demonstrate proficiency in drawing isometric views of springs.

Teaching Hints

The concept of springs is easy for many students to grasp. Some confusion occurs when differentiating between the types of ends available on compression springs. When teaching this chapter, be sure to give students applications regarding when a particular type of spring should and should not be used. It is one thing to be able to draw a spring, but it is another to actually decide what type and size to use.

After showing the class the PowerPoint slide presentation, pass out a variety of springs to the class and have them categorize the springs according to their type, intended purpose, and end design. Many science or technology education catalogs offer a variety of springs available for purchase. Students should see that although many springs are made to standard specification, there is a tremendous variety.

It is most important that students know how to draw schematic and simplified springs. Many CAD technicians do not have time, nor is it necessary, to draw the entire spring. Textbook problems given at the end of the chapter provide learning aids for students.

Chapter 15 Cams

Goal

The goal of this chapter is to teach students the basic principles and terms relating to cams.

Discussion Topics

1. Discuss the cam principle.

2. Compare the four basic types of followers.

3. Discuss the two major kinds of cams used in the industry.

4. Discuss the four main types of cam motion.

5. Discuss the development of timing diagrams.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the cam principle.

2. Describe the four basic types of followers.

3. Distinguish between the two major kinds of cams used in industry.

4. Define the most important cam terms.

5. Compare and contrast the four principal types of cam motion.

6. Demonstrate proficiency at laying out a cam from a displacement diagram.

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7. Demonstrate proficiency in drawing various types of cams.

8. Demonstrate proficiency in developing timing diagrams.

9. Demonstrate proficiency in dimensioning cams.

Teaching Hints

Distribute to the class a camshaft from a small gas engine. Many local repair shops have extra shafts that you could possibly borrow for this activity. Discuss what the purpose of each cam is and how it operates. Students should see that it is extremely important to draw these cams correctly because they must raise and lower the intake and exhaust valves at precise times. After showing the PowerPoint slide presentation, have students make sketches of what they think the displacement diagram will look like for each cam and the cams together.

Students should also be able to draw a cam based on the displacement diagram and vice versa. If possible, show how a cylindrical pattern development is similar to a displacement diagram. Have the students draw a cam and exchange it with a partner. It is very important that they dimension it correctly. The partner in turn will draw the displacement diagram and return it to the cam designer. The cam designer should check the displacement diagram for accuracy and then discuss it with a partner. Problems in the textbook provide additional supplemental drawings for the students.

Chapter 16 Gears

Goal

The goal of this chapter is to teach students how to identify and represent the different gear types.

Discussion Topics

1. Discuss the classifications of gears.

2. Define diametral and circular pitch.

3. Discuss terminology related to the profiles and kinematics of gears.

4. Discuss the use and function of a gear train.

5. Discuss worm gears.

Chapter Objectives

After studying this chapter you should be able to:

1. Identify different kinds of gears.

2. Discuss flexible drives such as chain and belt.

3. Discuss terms related to the profiles and kinematics of gears.

4. Determine the gear ratio between two gears.

5. Calculate train values of gear trains.

6. Construct an involute curve on a base circle.

7. Calculate the center distance between two gears in contact.

8. Prepare working drawings of gears.

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Teaching Hints

Students must learn three essential topics from this chapter to become competent in gear CAD techniques. First, it is important for students to learn the terminology and types of gears. Students should use a gear reference manual to look up and identify various types of gears and their function. They will notice that there are many more gears listed in these manuals than are shown in the text, but they can be divided into broad categories that are listed in the beginning of the chapter.

Second, students will need to be able to calculate gear ratios, gear teeth size, and train values. It will be important to review the basic process of calculating proportions and the parts of a circle. Show sample problems to the class to ensure that all students are competent with these calculations. If students will be required to draw gear teeth, they must be able to do advanced geometry and algebra. Review the required cutting data tables to familiarize the students with the formulas and how they relate to gear characteristics.

Finally, students should understand how gears work. Knowing all the formulas and terminology, without actually building or using something that has gears, does not make the information they have learned practical. Consider having students use Lego® blocks or similar building material to construct a gear train that changes direction, speed, torque, and even utilizes a worm or rack gear. If these are not available, have students go to a second-hand shop and purchase a device that utilizes gears. Then discuss these during class.

Chapter 17 Assembly and Detail Drawings for Design

Goal

The goal of this chapter is to teach students how to prepare sketches, layout drawings, detail drawings, and final assembly drawings.

Discussion Topics

1. Discuss the three sections of a typical engineering department and their interactions.
2. Discuss the use of sketches, layout drawings, detail drawings, subassembly drawings, and final assembly drawings.
3. Compare the technical drawing types used in industry.
4. Discuss the role of DFM and DFA in the manufacturing processes of a larger production company.
5. Discuss invention agreements and patent drawings.

Chapter Objectives

After studying this chapter you should be able to:

1. Discuss the use of sketches, layout drawings, detail drawings, subassembly drawings, and final assembly drawings.
2. Summarize the contents of a parts lists or a Bill of Materials (BOM), including purchased parts.
3. Prepare sketches, layout drawings, detail drawings, subassembly drawings, and final assembly drawings.
4. Describe a typical engineering department and the functions of a design section, an application department, and a quotation department.
5. Describe the design procedure used in industry and identify your own potential role in the procedure.
6. Compare the similarities and differences between a proposal and a contract.

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7. Process ECRs and ECOs.

8. Describe how a selling price is established for a product.

9. Start your own technical file in a systematic manner.

10. Explain DFM and DFA.

11. Recognize invention agreements and patent drawings.

Teaching Hints

This chapter may be the most foreign to traditional students. They have probably not worked in an engineering or design firm and therefore are not familiar with how such an operation functions. It is important that they gain experience in such a firm in a simulated, non-threatening way. Consider forming a company with the class. After discussing the chapter content and showing the PowerPoint slide presentation, list the various jobs that are found in a firm on the board. Discuss what the specific responsibilities for each position are and have the students decide what job they would like to assume. There should also be a management team.

Have students make a rough sketch of a product they either invent or improve. This can be written as a request for proposals from a fictional company that manufactures new products. Then the class should vote on which product they would like to see through the entire design process. The sketch should begin at the "engineering department" and proceed through the quotation department. The instructor should act as the client and meet with people in each department periodically; and request the particular information and drawings from each department and when it is due.

Finally, if possible, invite a guest speaker into the class, one who is involved in this process each day. This person can relate practical information that will be useful to students as they complete their education and begin looking for a job.

Chapter 18 Pictorial Drawings

Goal

The goal of this chapter is to teach students the skills required to facilitate, through pictorial drawings, the communication of technical information during all phases of the design process.

Discussion Topics

1. Discuss the purpose(s) of pictorial drawings.

2. Discuss the most common types of pictorial drawings.

3. Compare diametric and trimetric drawings.

4. Discuss cavalier drawings.

5. Discuss cabinet drawings.

Chapter Objectives

After studying this chapter you should be able to:

1. Explain the purpose of pictorial drawings.

2. Demonstrate proficiency in developing oblique drawings including cavalier and cabinet.

3. Demonstrate proficiency in developing isometric drawings including diametric and trimetric.

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4. Demonstrate proficiency in drawing circles, curves, and irregular shapes in isometric, on flat and inclined surfaces.

5. Demonstrate proficiency in developing one-, two-, and three-point perspective drawings.

Teaching Hints

Most students should be well accustomed to this chapter as many of the drawings shown in the book thus far have shown pictorial drawings. Show the students the PowerPoint slide presentation to familiarize them with any new terminology and review the techniques used to construct the various pictorial drawings. During the presentation have students sketch an example of each type of drawing and label important angles and notes.

When students are ready to make various pictorial drawings, review the basics of multiview drawings. This is important because most of the pictorial drawings are based on the principles of multiview drawings. Then give each student a multiview drawing that incorporates a circle, arc, and variety of surfaces. The problems presented in the end of the chapter can be used for these exercises. Students can then draw this object as an isometric, oblique, and two-point perspective. This is the best way for students to understand the advantages and disadvantages of these drawing types. Particular attention needs to be given to drawing circles and curves because many students do not orient these correctly on the surface. Finally, students should complete the CAD exercises. Be sure students know how to set the isometric grid and turn it on and off, which will aid in drawing axonometric or oblique drawings.

Chapter 19 Welding

Goal

The goal of this chapter is to teach students the welding process as it relates to technical drawing and CAD.

Discussion Topics

1. Discuss the most widely used welding procedure.

2. Identify the basic welding symbols.

3. Compare the three kinds of contour symbols.

4. Compare the five basic kinds of welding joints.

5. Compare the six major types of welds.

6. Discuss the nature and uses of spot welding.

7. Discuss the nature and uses of the seam weld.

Chapter Objectives

After studying this chapter you should be able to:

1. List the most widely used welding procedure.

2. Demonstrate proficiency in the proper use of welding symbols.

3. Demonstrate proficiency in the proper dimensioning of welds.

4. Demonstrate proficiency in properly indicating weld placement.

5. Demonstrate proficiency in properly indicating intermittent welds.

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6. Explain the proper use of the contour symbols as part of the welding symbol.

7. Explain the proper use of the symbology for field welds.

8. Describe the five basic types of welded joints.

9. Describe the six major types of welds.

10. Demonstrate proficiency in the proper use of multiple reference lines.

11. Explain the concept of spot welding.

12. Explain the differences between spot welds and projection welds.

13. Explain the concept of the seam weld.

14. Demonstrate proficiency in the use of welding templates.

Teaching Hints

Students must understand the basic principles of welding and the symbols that are used to specify a particular weld. Begin with the PowerPoint slide presentation to introduce students to the basic welding techniques. Have students look at various products to examine the welding techniques that were used. If possible, provide students with an opportunity to weld two pieces of metal. By doing this they will develop a better understanding of why welds are called out by using specific techniques. Students will also begin to appreciate the amount of practice it takes to become a skilled welder.

Discuss the chart in the chapter that shows the welding symbols (see Figure 19-2). Students could make index cards that summarize the basic principles of the most commonly used symbols. They will use these throughout the chapter as they learn additional symbols and complete drawings. The cards will also provide an opportunity for students to draw all the symbols and ask questions when necessary.

Another way to learn the symbols is to give students an orthographic drawing and, as a class, add the welding symbols to it. This will provide a good chance to go over the symbols as they are used on the drawing and use the textbook as a reference guide. As additional drawings are introduced, students should complete them in pairs. They can then cooperatively solve the problems at the end of the chapter. Finally, continuously reinforce the importance of accurately specifying welds. In some cases it can be the difference between a product functioning safely and one that fails under a given load.

Chapter 20 Modern Manufacturing: Materials, Processes, and Automation

Goal

The goal of this chapter is to teach students the basic processes used to fabricate objects as well as the capabilities and limitations of the tools used to render these objects into their final form.

Discussion Topics

1. Describe various engineering materials.

2. Discuss the most widely used types of metals in modern manufacturing.

3. Compare the most common types of forging processes.

4. Discuss the principal types of casting processes.

5. Discuss the most common machining processes.

6. Discuss the concepts of jigs and fixtures.

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7. Discuss the most widely used nontraditional machining processes.
8. Discuss the concept of computer-aided manufacturing (CAM).
9. Discuss the concept of computer-integrated manufacturing (CIM).
10. Discuss the concept of the flexible manufacturing system (FMS).

Chapter Objectives

After studying this chapter you should be able to:

1. Define the concept of engineering materials.
2. Distinguish between the two broad categories of engineering materials.
3. List the most widely used types of metals in modern manufacturing.
4. List the most widely used nonmetals in modern manufacturing.
5. Define the term *composites*.
6. Describe the principal types of casting processes.
7. Describe the most common types of forging processes.
8. Define the term *machining*.
9. Describe the most common machining processes.
10. Explain the concept of computer-numerical-controlled machines.
11. Explain the concept of jigs.
12. Explain the concept of fixtures.
13. Describe the most widely used nontraditional machining processes.
14. Explain the concept of automation.
15. Explain the concept of computer-aided manufacturing (CAM).
16. Define the term *robot*.
17. Explain the concept of computer-integrated manufacturing (CIM).
18. Explain the concept of the flexible manufacturing system (FMS).

Teaching Hints

This chapter allows students to synthesize the information they have learned thus far and apply it to the realm of manufacturing. Without a basic understanding of the manufacturing process, students will not have a complete grasp of CAD. If possible, visit a local manufacturing firm and have students interview a supervisor, CAD technician, CNC operator, quality control inspector, and a manual machine operator. They should ask questions to find out the importance of understanding the entire manufacturing process and creating accurate drawings. Students should also research a new computerized manufacturing

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operation, metallic alloy, or automation and report back to the class with a written or oral summary. This will give every student a more current understanding of a high-tech manufacturing process.

Following the PowerPoint slide presentation, students should complete the CAD problems. In addition, have students identify what type of machinery will be needed to manufacture that part. For instance, if the piece is to be machined, how will it be cut? How will it be drilled? If it is to be cast, what kind of metal is most appropriate? Although a CAD technician may not usually answer or even pose these types of questions, to be well rounded they should be able to think through the entire manufacturing process.

Chapter 21 The Design Process and Advanced Concepts

Goal

The goal of this chapter is to teach students the phases and steps of the design process.

Discussion Topics

1. Discuss the phases and steps of the design process.
2. Discuss the various techniques for complementing the design process.
3. Describe the technical drawings used in the design process.
4. Discuss the sources of design information.
5. Discuss the modern design practices and standards.
6. Discuss the objectives of DFM, DFA, DFR, and DFD.
7. Discuss the concepts of rapid prototyping, parametric design, ISO 9000, and reverse engineering.
8. Discuss the roles of drafters, designers, and engineers in the steps of the design process.

Chapter Objectives

After studying this chapter you should be able to:

1. Follow the phases and steps in the design process to do a routine design project as an individual effort.
2. Follow the phases and steps in the design process to do a non-routine design project as a member of a team.
3. Use various techniques to enhance the steps in the design process such as the creative process, attribute listing, decision table, and model building (actual and computer generated).
4. Use various information sources to augment the steps in the design process such as vendor catalogs, technical texts, technical periodicals, and technical handbooks.
5. Identify the various types of technical drawings you would use in the design process such as freehand sketches, design development layout drawings, kinematic layout drawings, and detail and assembly drawings.
6. Discuss the objectives of DFM, DFA, DFR, and DFD.
7. Recognize current trends in manufacturing.
8. Identify the roles of drafters, designers, and engineers in the steps of the design process.

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Teaching Hints

This chapter provides a culminating experience for the student. The content in the textbook can be applied to the design process as it is discussed in this chapter. Following a class discussion about the design process and presentation of the PowerPoint slide presentation, students could be divided into groups of four. They should choose a product to invent or improve and mutually agree on it. Then, by following the design process given in the chapter, they should create the drawings for this product and build a model of it. Although not every step of the design process is possible in a classroom scenario, the process as a whole provides a rich experience in solving a design problem. Each step of the design process should be documented in a design portfolio. This can be done either by the entire group or by individuals.

The instructor should act as the client. Regular report, updates, and presentations need to be scheduled with the instructor. To further enhance this activity, ask two or three other instructors to act as a panel to which the final project is presented. Throughout the activity, it is also beneficial to invite company representatives to the class to share how their products are developed, marketed, and sold. Finally, this chapter should provide the most realistic scenario from which the students learn. These experiences are extremely valuable as they enter the workforce with current drafting, CAD, interpersonal, teamwork, and practical skills.

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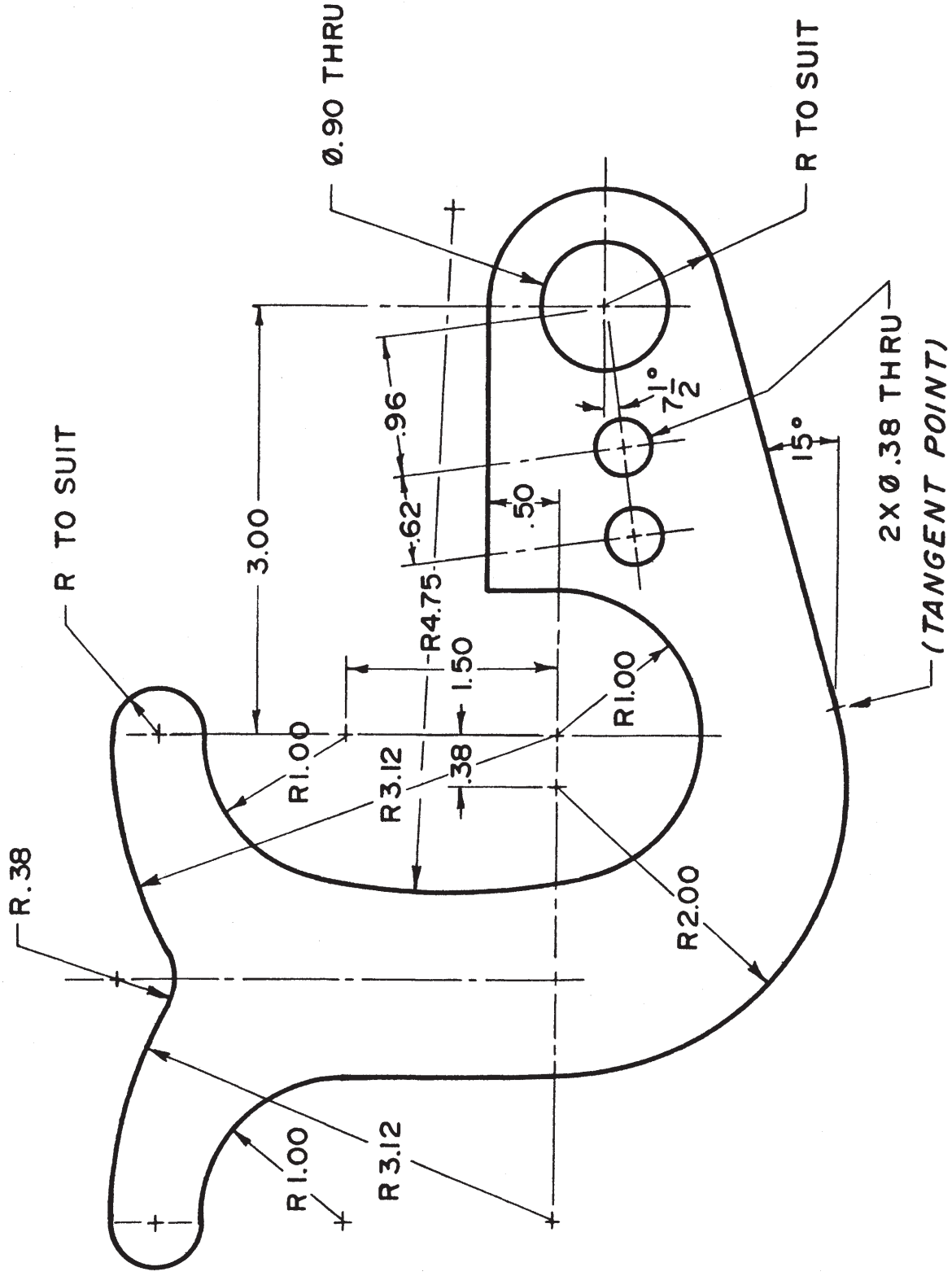
DRAWING TESTS

Q 4–1 Center this object full size on an A-size sheet of vellum. Use correct line thickness; show all light construction work. Do *not* add dimensions.



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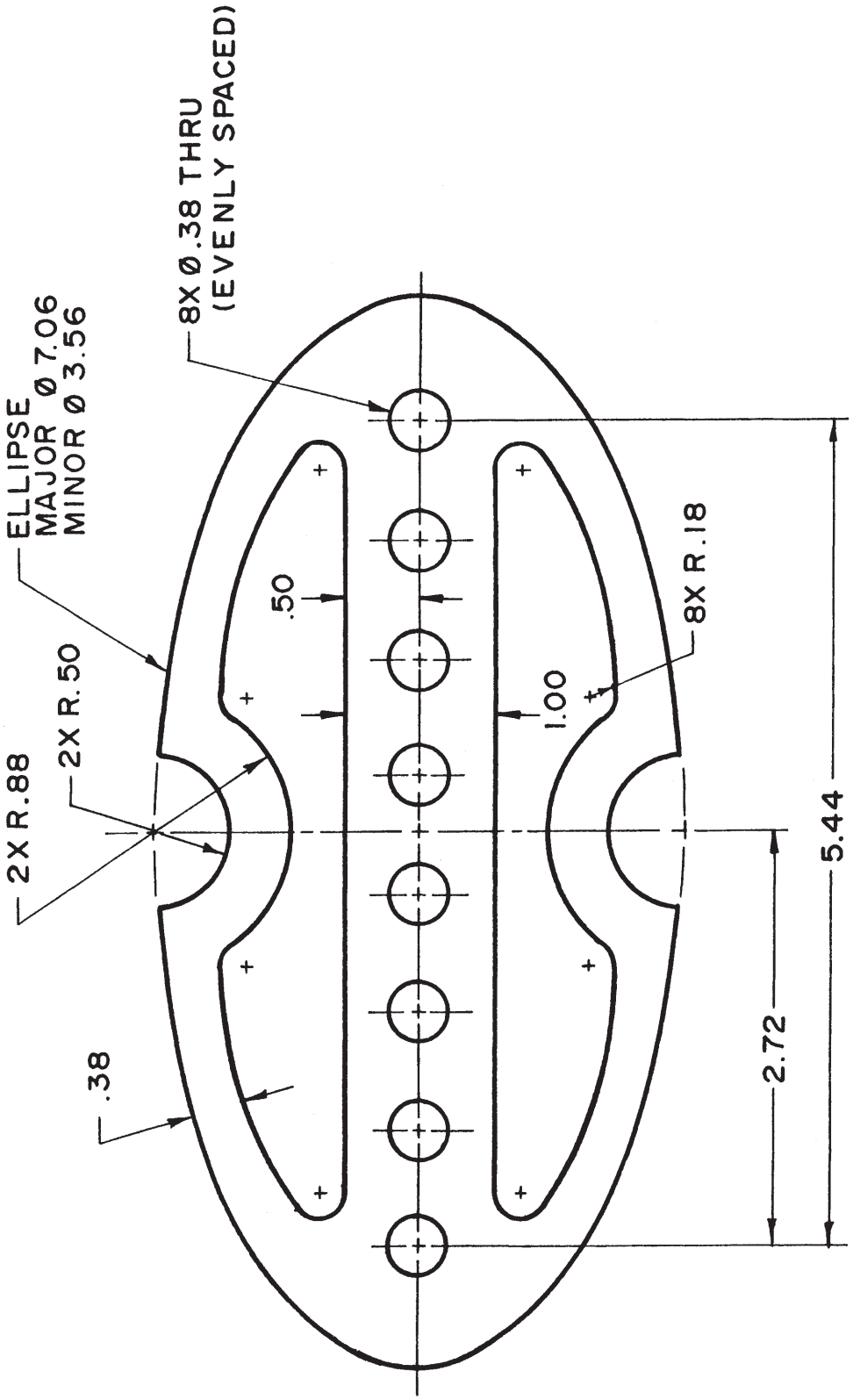
Q 4–2 Center this object full size on an A-size sheet of vellum. Use correct line thickness; show all light construction work. Do *not* add dimensions.



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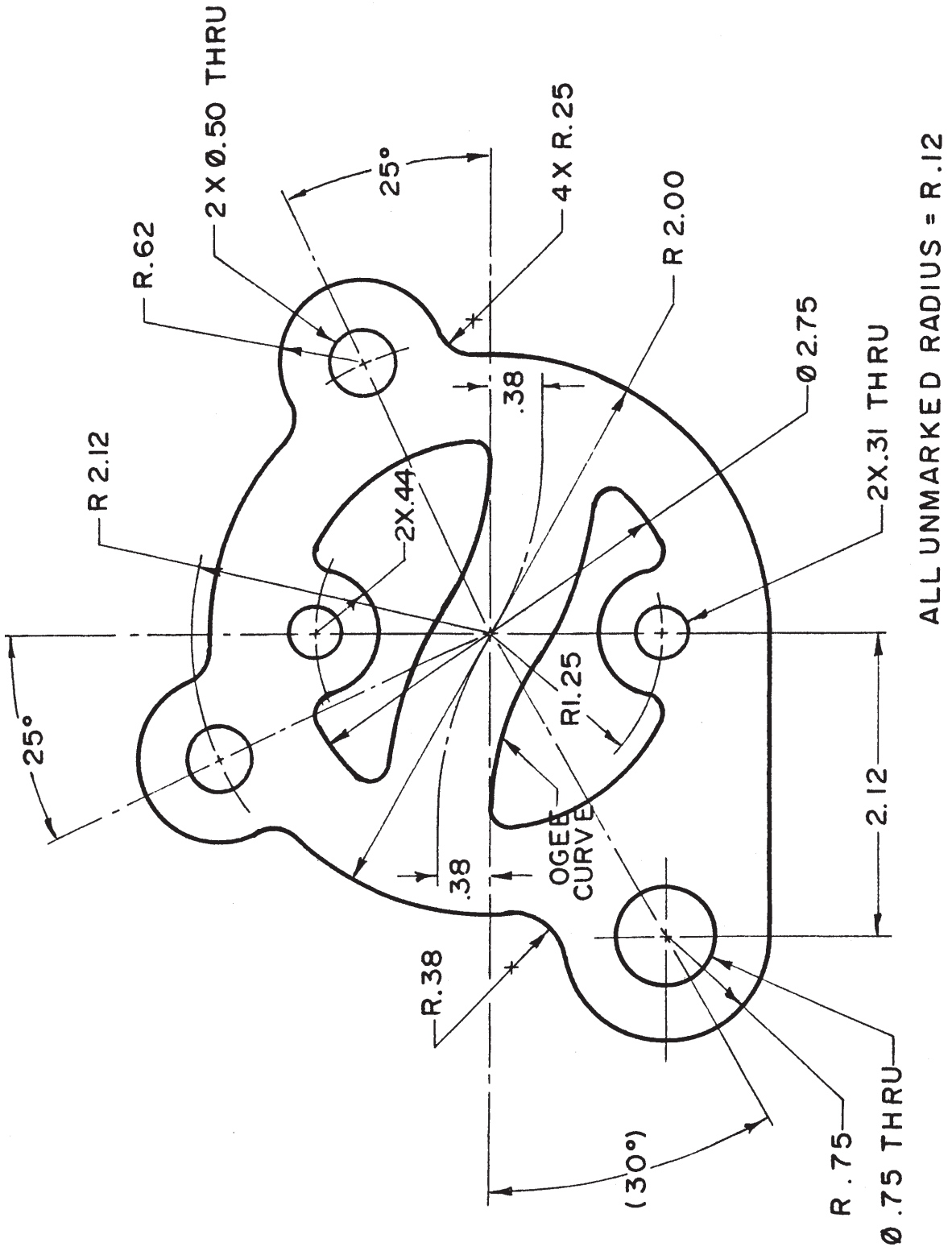
Q 4–3 Center this object full size on an A-size sheet of vellum. Use correct line thickness. Do *not* add dimensions.



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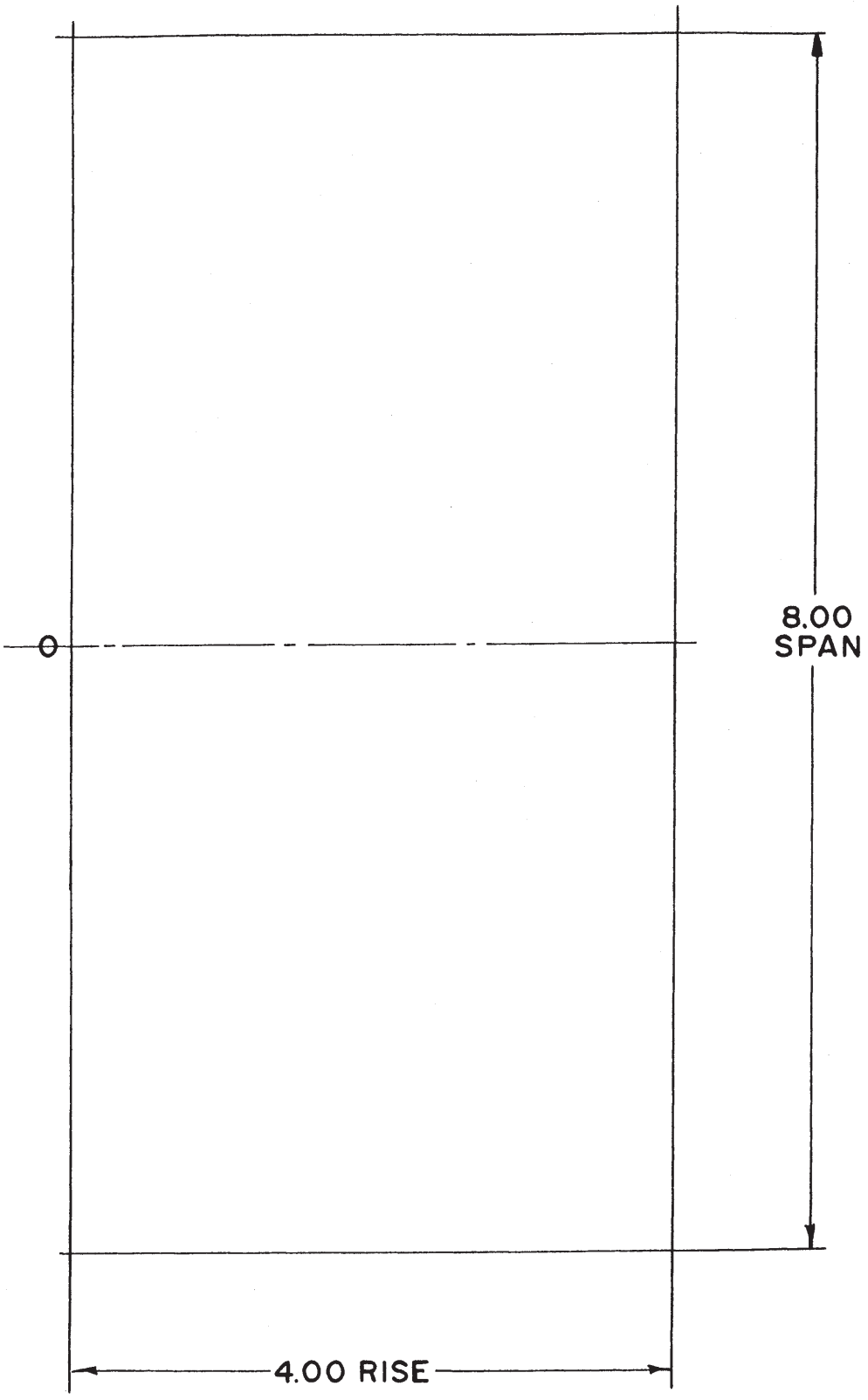
Q 4–4 Given: span and rise. Draw a parabola and locate its focal point.



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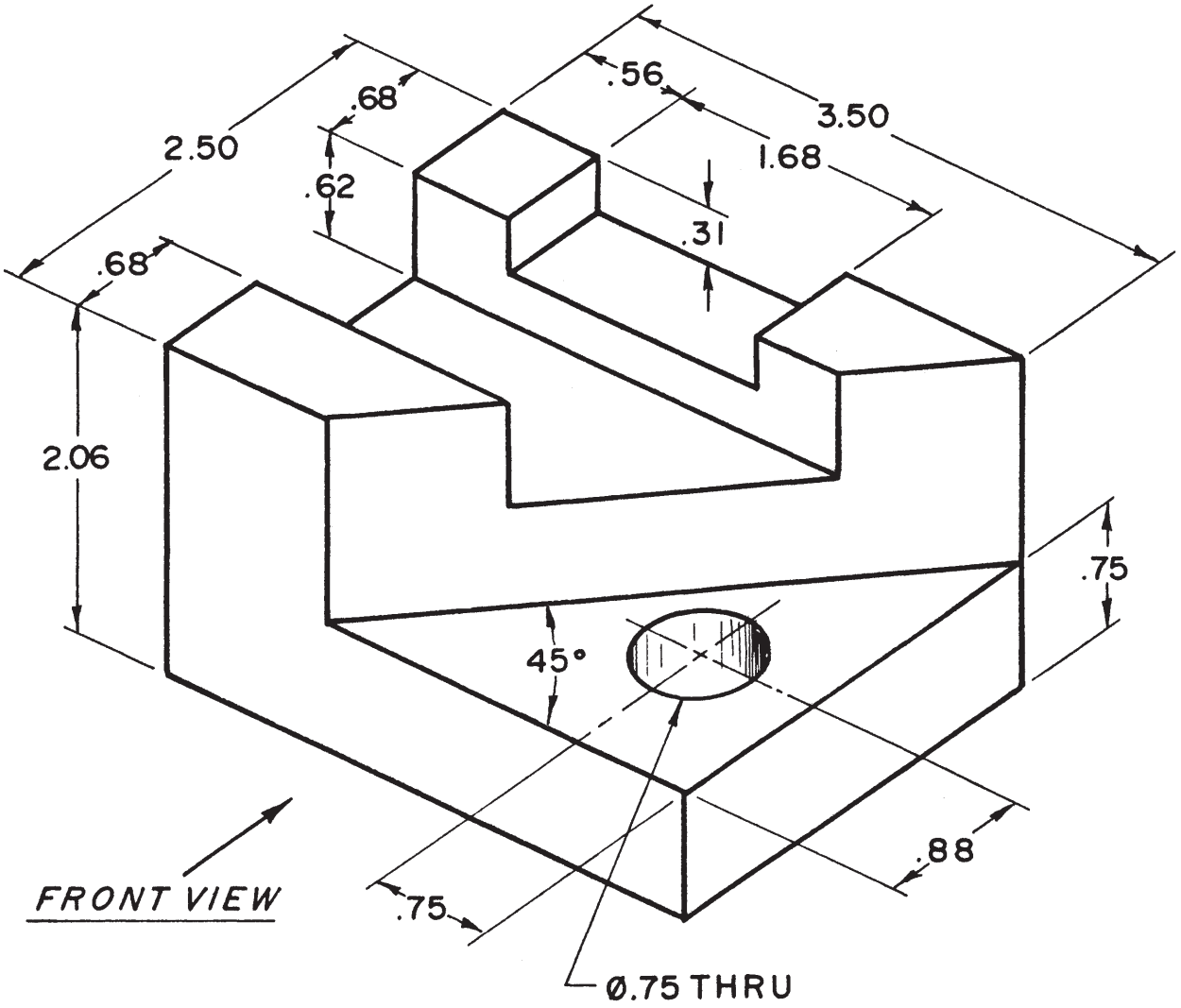
Q 5–1 Center three views of this object on an A-size sheet of vellum. Use correct line thickness; leave a 1-inch space between views. Do *not* add dimensions.



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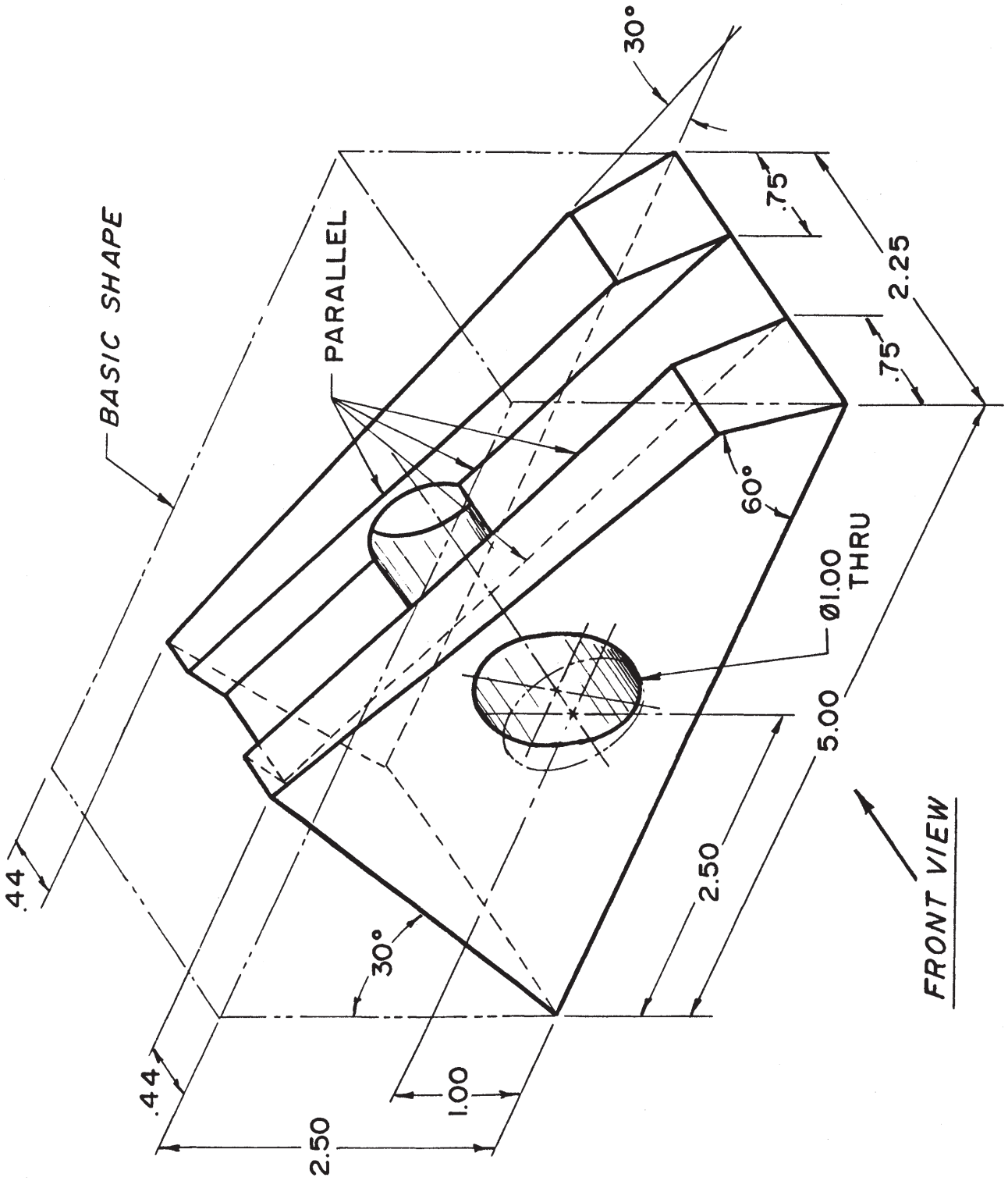
Q 5–2 Center three views of this object on an A-size sheet of vellum. Use correct line thickness; leave a 1-inch space between views. Do *not* add dimensions.



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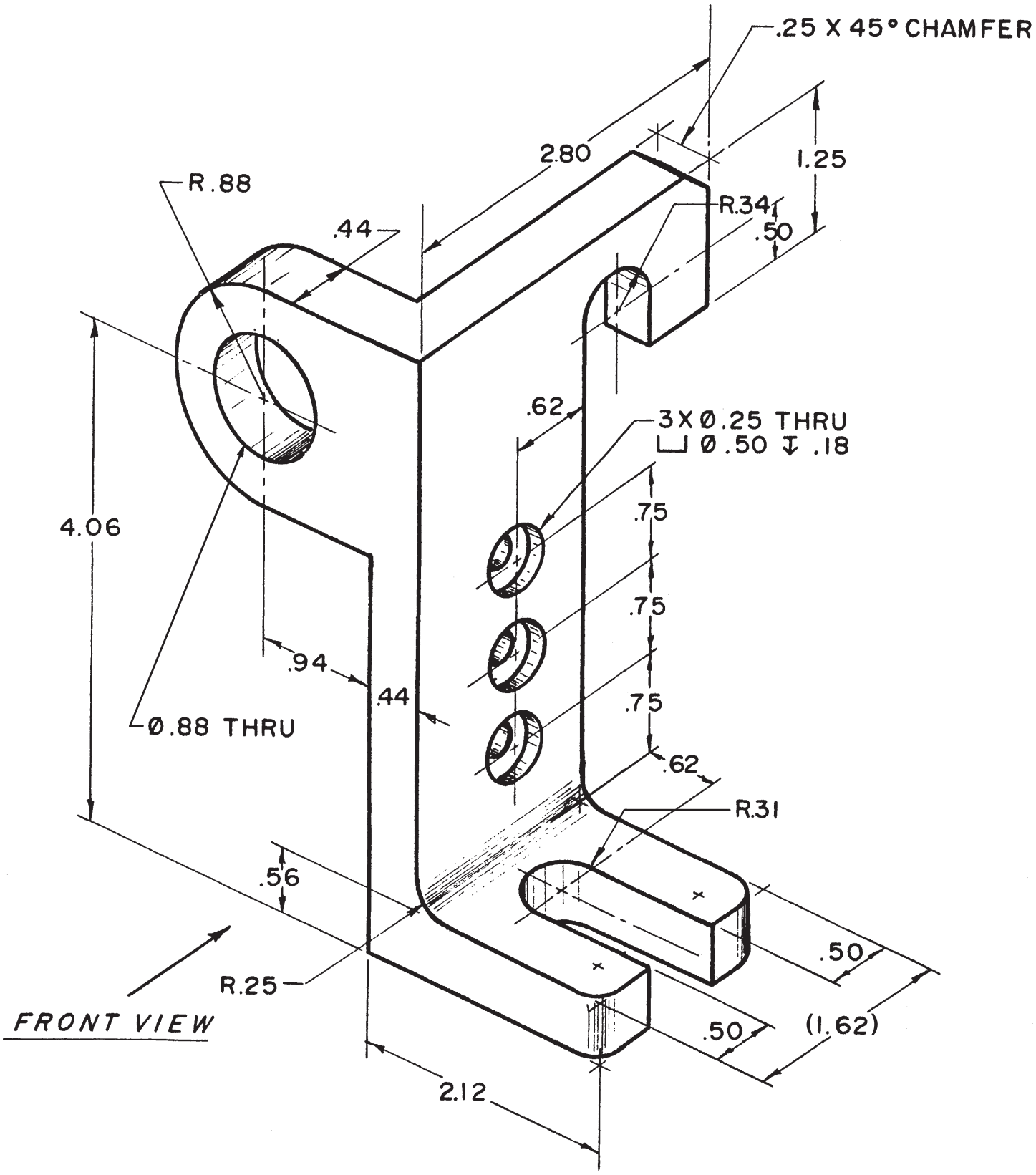
Q 5–3 Center three views of this object on an A-size sheet of vellum. Use correct line thickness; leave a 1-inch space between views. Do *not* add dimensions.



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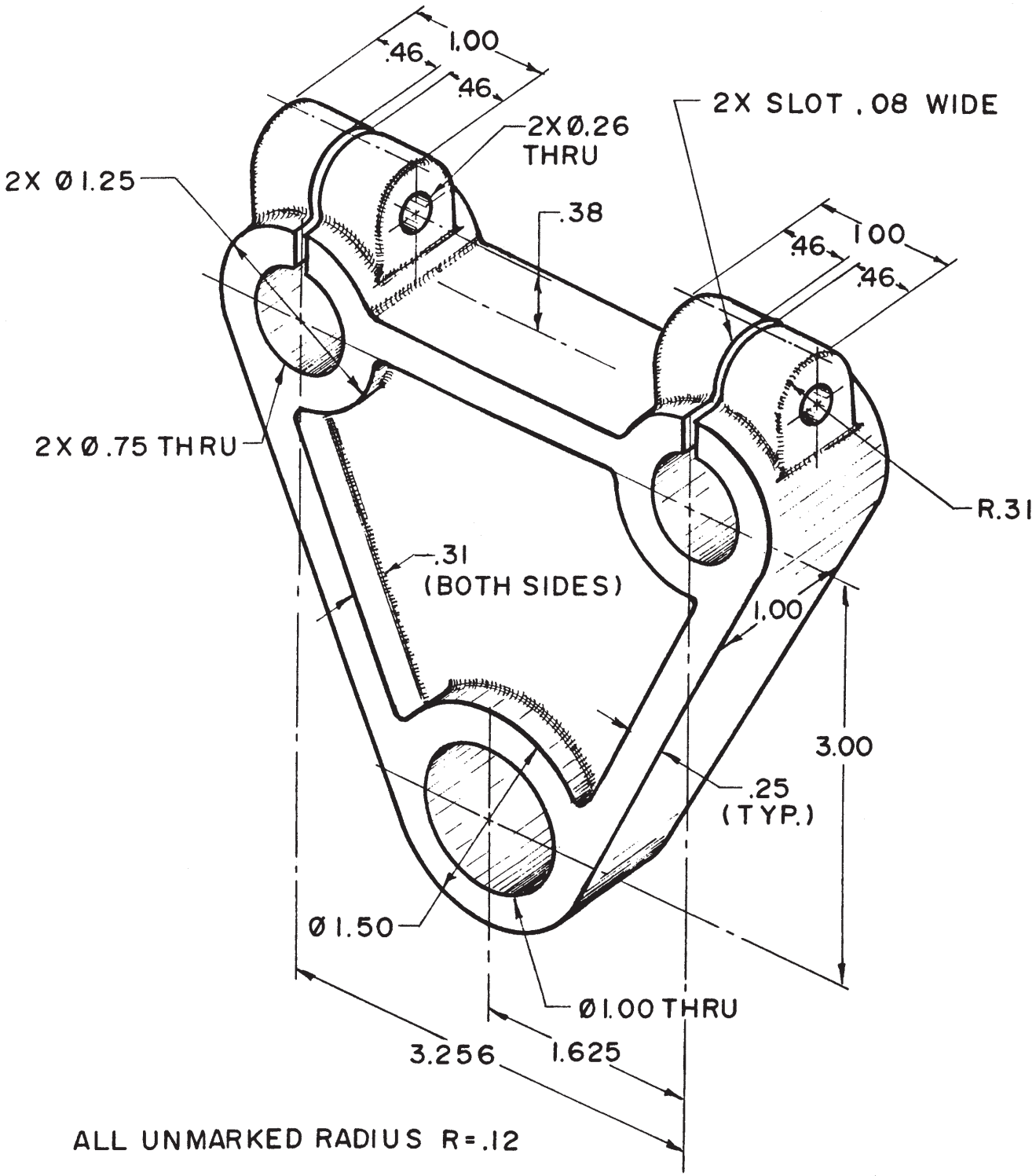
Q 5–4 Center three views of this object on an A-size sheet of vellum. Use correct line thickness; leave a 1-inch space between views. Do *not* add dimensions.



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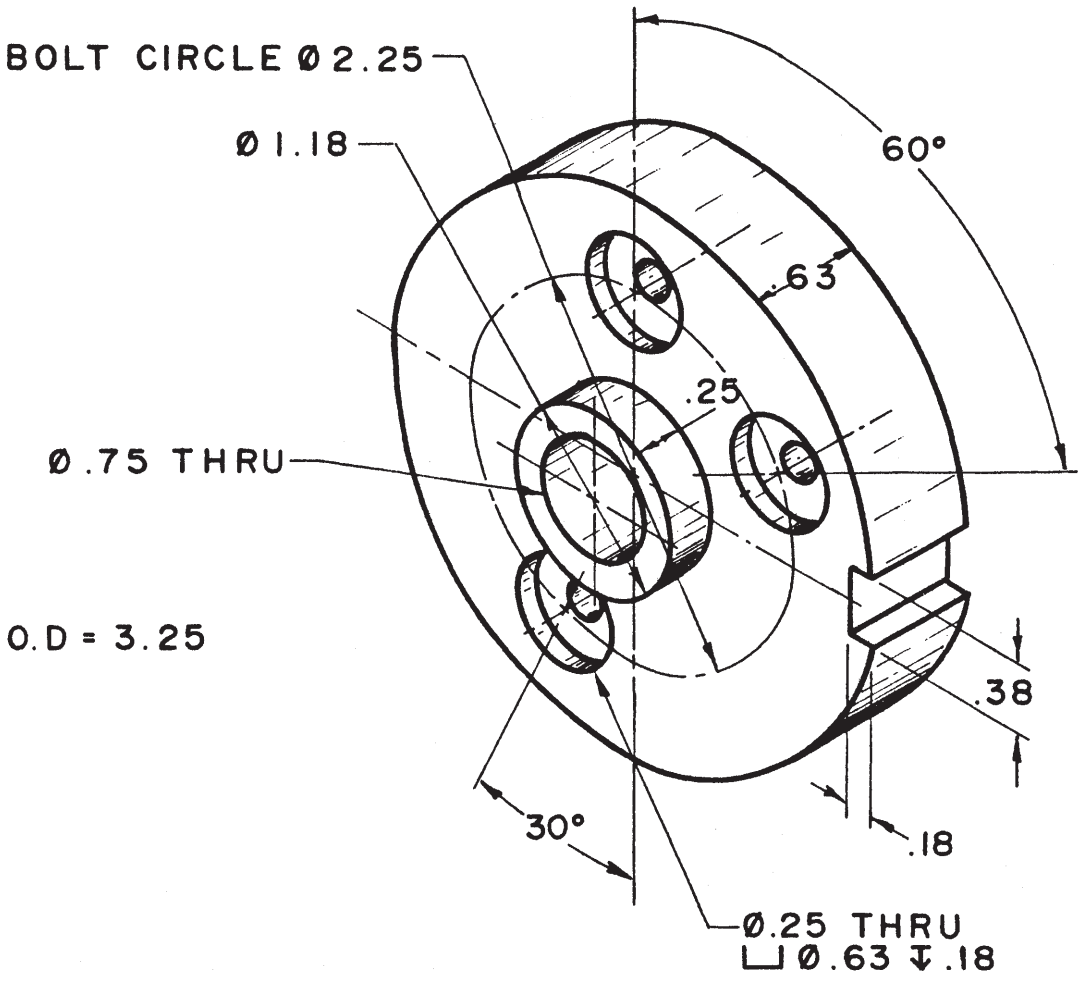
Q 6–1 Fully dimension this object using an *angular* system. Use correct line thickness and the latest drafting standards.



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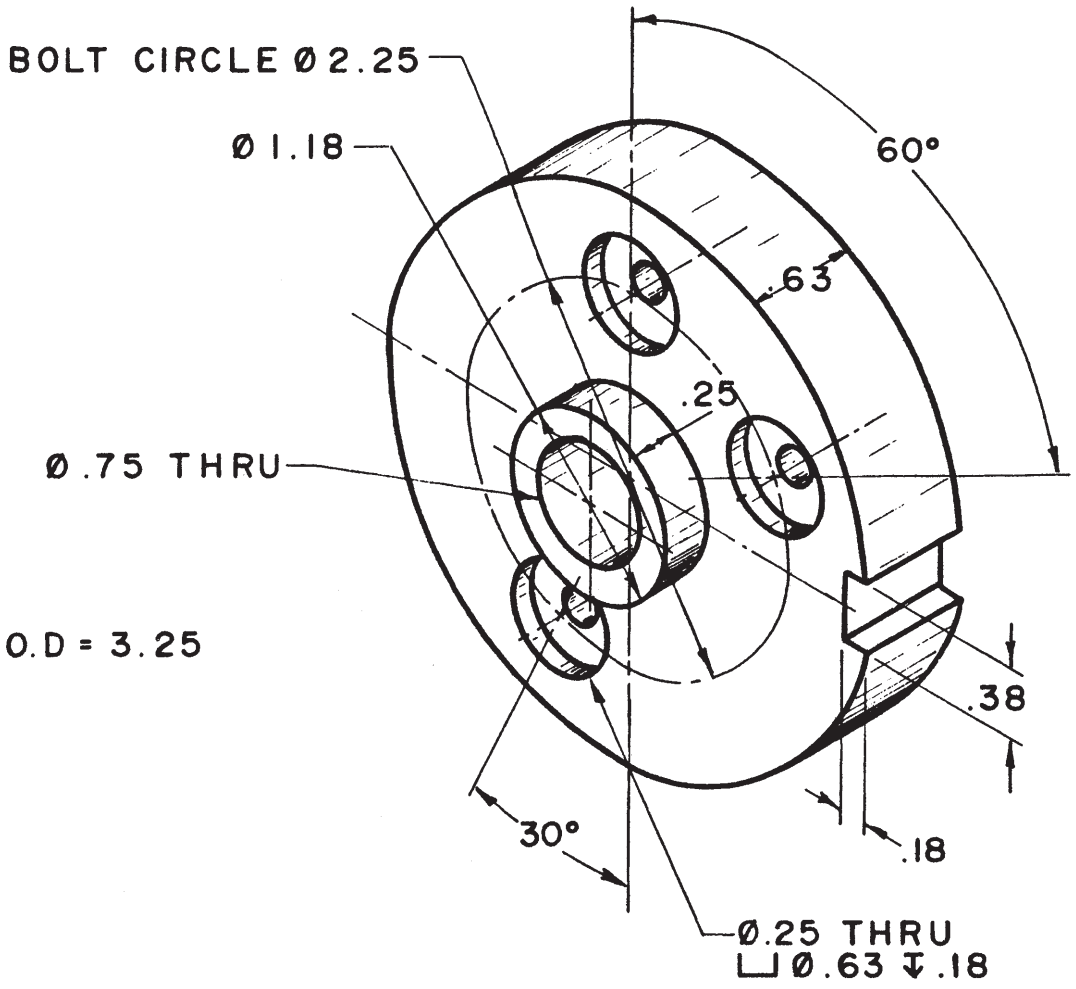
Q 6–2 Fully dimension this object using a *coordinate* system. Use correct line thickness and the latest drafting standards.



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