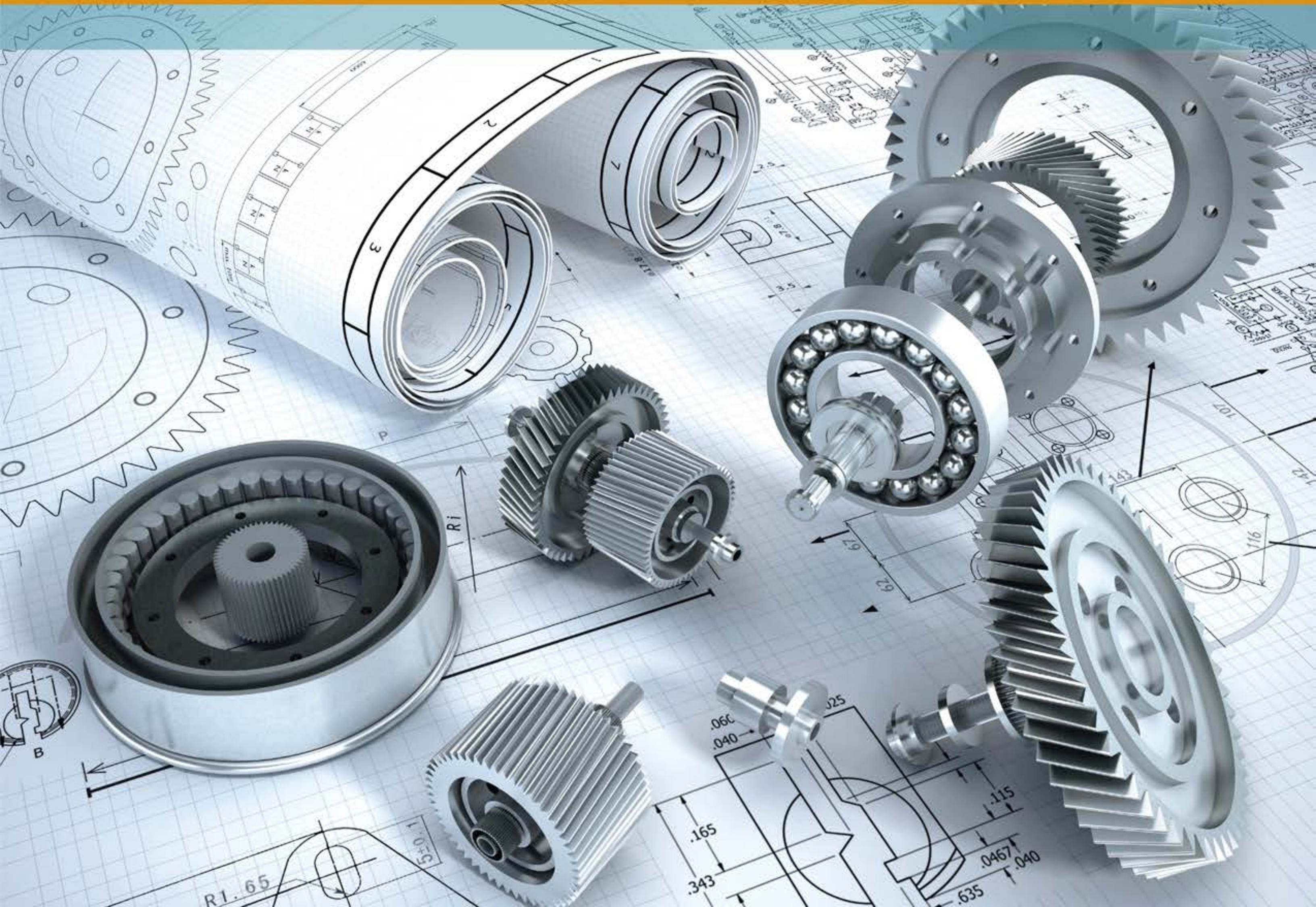
INTERPRETING ENGINEERING DRAWINGS

EIGHTH EDITION

THEODORE J. BRANOFF



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EIGHTH EDITION

THEODORE J. BRANOFF

Illinois State University

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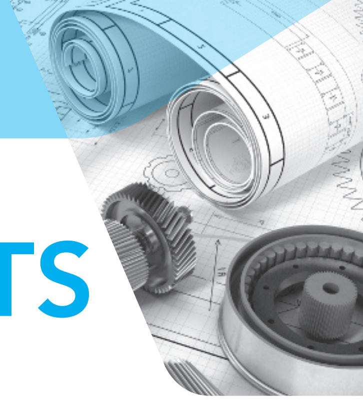

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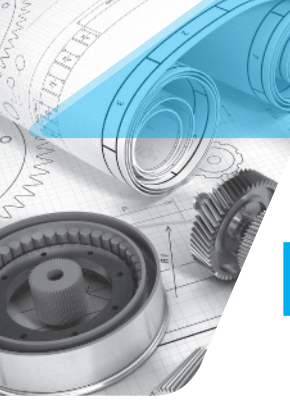

PREFACE

The eighth edition of *Interpreting Engineering Drawings* is the most comprehensive and up-to-date text of its kind. The text has been revised to best prepare students to enter twenty-first-century technology-intensive industries. It is also useful to those individuals working in technology-based industries who feel the need to enhance their understanding of key aspects of twenty-first-century technology. To that end, the text offers the flexibility needed to provide instruction in as narrow or as broad a customized program of studies as is required or desired. Clearly, it provides the theory and practical application for individuals to develop the intellectual skills needed to communicate technical concepts used throughout the international marketplace.

Flexibility is the key to developing a program of studies designed to meet the needs of every student. *Interpreting Engineering Drawings,* eighth edition, is designed to allow instructors and students to pick and choose specific units of instruction based on individual needs and interests.

Although students should cover everything offered in the core material in the text (Units 1 through 17), advanced topics are offered throughout the remaining 28 units to provide opportunities for students to become highly skilled in understanding only selected advanced subjects or a broad range of subjects that spread over nearly all aspects of modern industry. Additionally, ancillary materials offered on the Instructor Companion Website, as well as the Internet Resources listed at the end of each unit, provide for a more in-depth understanding of the material covered. Through the use of these ancillary materials, the depth of understanding achieved is limited only by the student's time constraints and the desire to master the material provided.

It is important to know that the entire text is developed around the most current standards accepted throughout industry. This includes both decimal-inch and metric (millimeter) sizes and related concepts. Both systems are introduced early in the text and are reinforced in both theory and practical application through the broad range of assignments at the end of each unit. These concepts are further reinforced as students are encouraged to use the Appendix at the end of the text. Tables in the Appendix are given in both systems of measure.

Features that made *Interpreting Engineering Drawings* highly successful in previous editions continue to be used in the eighth edition. For example, as always, the text carefully examines the very basic concepts needed to understand technical drawings and meticulously and methodically takes the student through progressively more complex issues. Plenty of carefully developed illustrations, reinforced by the use of a second color, provide a clear understanding of material covered in the written text. Assignments provided at the end of each unit are designed to measure the student's understanding of the material covered as well as reinforce the theoretical concepts.

Further, only after the student develops a clear understanding of basic concepts is he or she introduced to more advanced units such as modern engineering tolerancing (geometric dimensioning and tolerancing), manufacturing materials and processes, welding drawings, piping, and other similar advanced topics.

Although *Interpreting Engineering Drawings* has always used sketching practices as a means of reinforcing the student's understanding of technical information, the eighth edition greatly expands this important technique. Not only does sketching enhance the student's understanding of technical concepts, it also enhances his or her ability to communicate technical concepts more effectively.

In keeping with the dynamic changes in the field of engineering graphics, various new features have been added to this eighth edition.

FEATURES OF THE EIGHTH EDITION

- *New and revised figures.* Figures have been added and revised to clarify national and international standards including line types, first-angle projection, developments, selection and arrangement of views and to clarify the applications of geometric dimensioning and tolerancing.
- *Standards update*. All drawings in the text have been updated to conform to the latest ASME drawing standards.
- *Internet resources*. Internet sources have been revised and search terms have been added to help students find useful additional resources on unit material.

The authors and the publisher hope you find the eighth edition of *Interpreting Engineering Drawings* to be as practical and useful as you have the previous editions.

Please feel free to contact us through the publisher if you have questions or comments about the book.

SUPPLEMENTS

The Instructor Companion Website to Accompany *Interpreting Engineering Drawings* offers free resources for instructors to enhance the educational experience. The Website contains unit presentations in PowerPoint™, Grid Sheets, Assignments List, Lesson Plans, Assignment Solutions, Test Assignments and Solutions, and an Image Gallery.

Accessing an Instructor Companion Website from SSO Front Door

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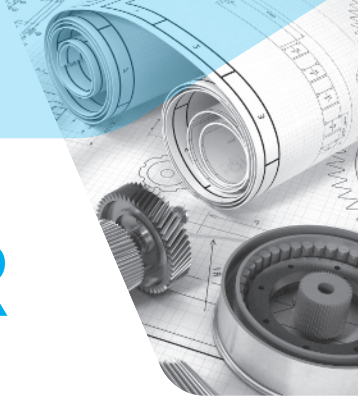

ABOUT THE AUTHOR

Theodore J. Branoff, Ph.D. is currently a member of the Engineering Design Graphics Division of the American Society for Engineering Education; the Association of Technology, Management, and Applied Engineering; the International Society for Geometry and Graphics; the International Technology and Engineering Educators Association; the Associate for Career and Technical Education; and Epsilon Pi Tau. He served as president of ISGG from 2009 to 2012. In 2013 he was elected into the Academy of Fellows of the American Society for Engineering Education, and in 2014 he received the Distinguished Service Award from the Engineering Design Graphics Division of ASEE.

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Ed Espin, Burlington, Ontario, Canada

UNIT 1

INTRODUCTION: LINE TYPES AND SKETCHING

BASES FOR INTERPRETING DRAWINGS

Commonly Used Descriptive Terms

When looking at objects, we normally see them as three-dimensional—as having width, depth, and height; or length, width, and height. The choice of terms used depends on the shape and proportions of the object.

Spherical shapes, such as a basketball, would be described as having a certain *diameter* (one term).

Cylindrical shapes, such as a baseball bat, would have *diameter* and *length.* A hockey puck would have *diameter* and *thickness* (two terms).

Objects that are not spherical or cylindrical require *three* terms to describe their overall shape. The terms used for a car would probably be *length, width,* and *height;* for a filing cabinet—*width, height,* and *depth,* even though the longest measurement (length) could be the width, height, or depth; for a sheet of drawing paper—*length, width,* and *thickness.* The terms used are interchangeable according to the *proportions* of the object being described, and the *position* it is in when being viewed. For example, a telephone pole lying on the ground would be described as having *diameter* and *length,* but when placed in a vertical position, its dimensions would be *diameter* and *height.*

In order to avoid confusion, distances from left to right are referred to as *width,* distances from front to back as *depth,* and vertical distances (except when very small in proportion to the others) as *height.*

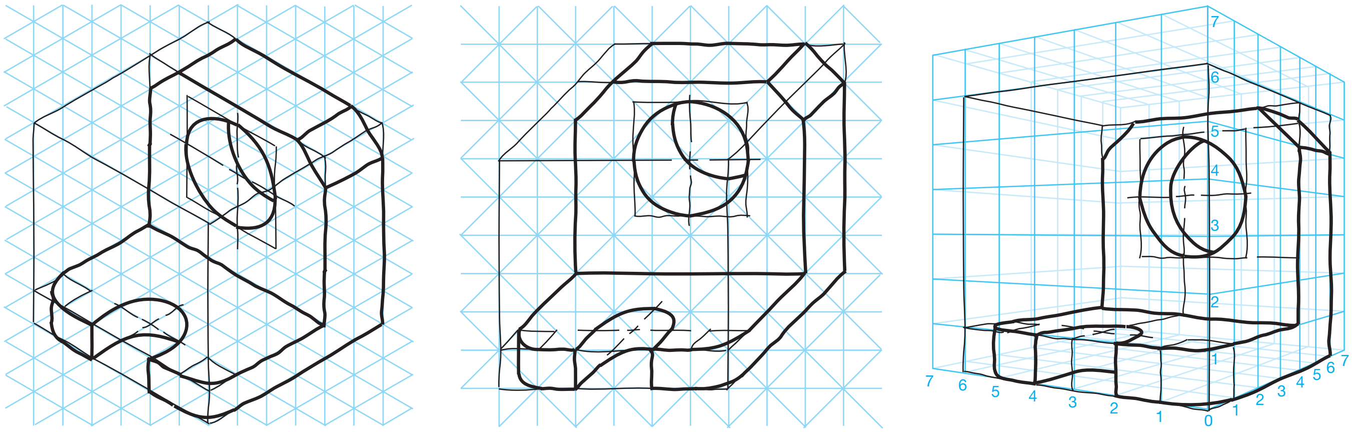
The Need for Standardization

Engineering drawings are more complicated and require a set of rules, terms, and symbols that everyone can understand and use. A drawing showing a part may be drawn in New York, the part made in California, and then sent to Michigan for assembly. If this is to be successfully accomplished, the drawing must have only one interpretation.

Most countries set up standards committees to accomplish this feat. These committees must decide on factors such as the best methods of representation, dimensioning and tolerancing, and the adopting of drawing symbols. Different styles of lines must be established to represent visible or hidden lines, or to indicate the center of a feature. If only one interpretation of a drawing is to be met, then the rules must be followed and interpreted correctly.

In the United States, drawing standards are established by the *American Society of Mechanical Engineers* (ASME) and in Canada, by the *Canadian Standards Association* (CSA). Members of these committees are part of the worldwide committee on standardization, known as the *International Organization for Standardization* (ISO).

FIGURE 1–1 Pictorial sketches.



(A) ISOMETRIC SKETCH **(B) OBLIQUE SKETCH** **(C) PERSPECTIVE SKETCH**

The drawings and information shown throughout this text are based on the ASME-Y14 Series of Drawing Standard Practices. In some areas of drawing practice, such as in simplified drafting, national standards have not yet been established. The authors have, in such cases, adopted the practices used by leading industries in the United States.

Engineering or *technical drawings* furnish a description of the shape and size of an object. Other information necessary for the construction of the object is given in a way that renders it readily recognizable to anyone familiar with engineering drawings.

Pictorial drawings are similar to photographs, because they show objects as they would appear to the eye of the observer, Figure 1–1. Such drawings, however, are not often used for technical designs because interior features and complicated details are easier to understand and dimension on orthographic drawings. The drawings used in industry must clearly show the exact shape of objects. This usually cannot be accomplished in just one pictorial view because many details of the object may be hidden or not clearly shown when the object is viewed from only one side.

For this reason, the drafter must show a number of views of the object as seen from different directions. These views, referred to as front view, top view, right-side view, and so forth, are systematically arranged on the drawing sheet and projected from one another, Figure 1–2. This type of projection is called *orthographic projection* and is explained in Unit 4. The ability to understand and visualize an object from these views is essential in the interpretation of engineering drawings.

ENGINEERING DRAWINGS

Throughout the history of engineering drawings, many drawing conventions, terms, abbreviations, and practices have come into common use. It is essential that all drafters, designers, and engineers use the same practices if drafting and sketching are to serve as a reliable means of communicating technical theory and applications.

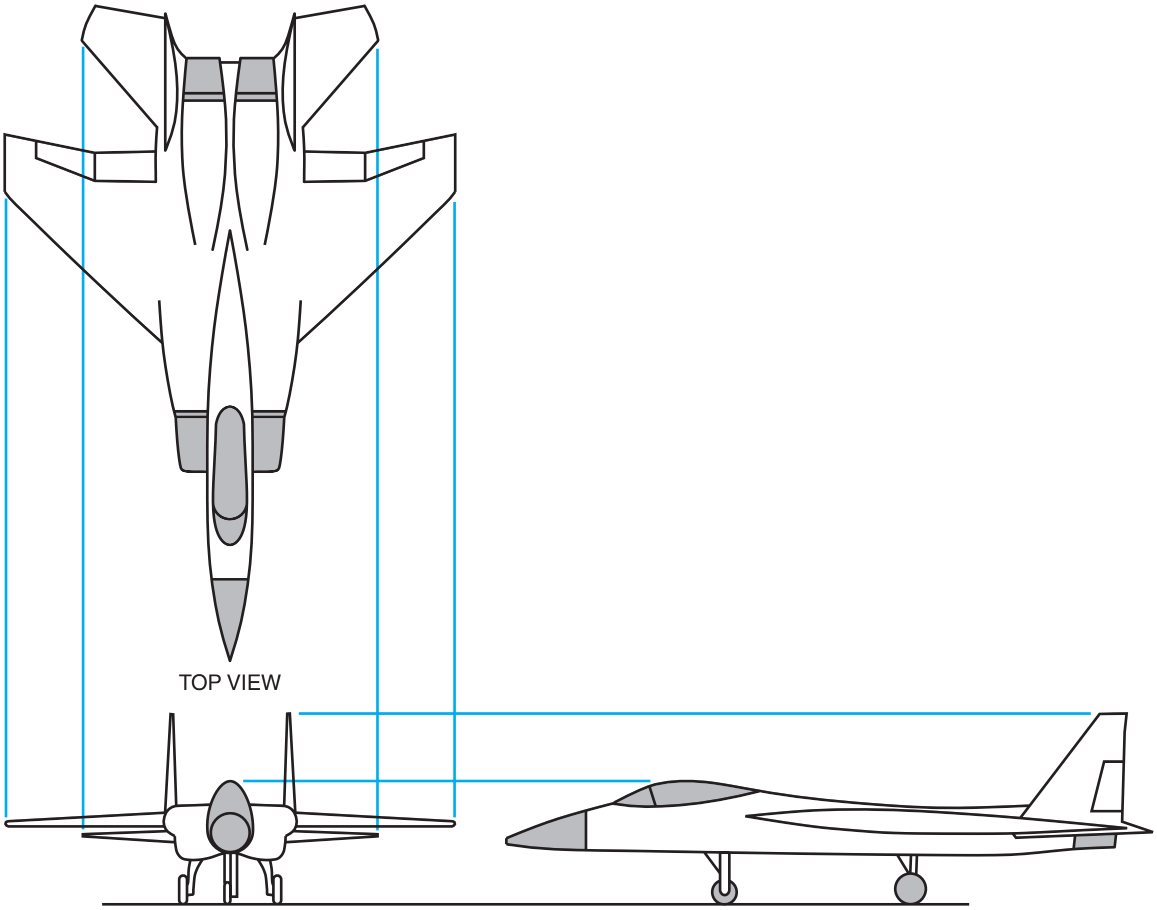
An engineering drawing consists of a variety of line styles, symbols, and lettering. When positioned correctly on the drawing paper, they convey precise information to the reader.

LINES USED TO DESCRIBE THE SHAPE OF A PART

Line Styles

Most objects drawn in engineering offices are complicated and contain many surfaces and edges. For this reason, a line is the fundamental, and

FIGURE 1–2 Systematic arrangement of views.



perhaps the most important, single entity on an engineering drawing. Lines are used to illustrate and describe the shape and size of objects that will later become real parts. The various lines used on engineering drawings form the alphabet of the drafting language. Like letters of the alphabet, they are different in their appearance. Some are light—others are dark. Some are thick—others are thin. Some are solid—others are dashed in various ways. Figure 1–3 illustrates the various types of lines used in engineering drawing. These will be explained in more detail throughout the units of this textbook.

Construction Lines

When first laying out a sketch, light, thin, solid lines are used to develop the shape and location of features. These lines are called *construction* lines, and being very thin and light, are normally left on the sketch.

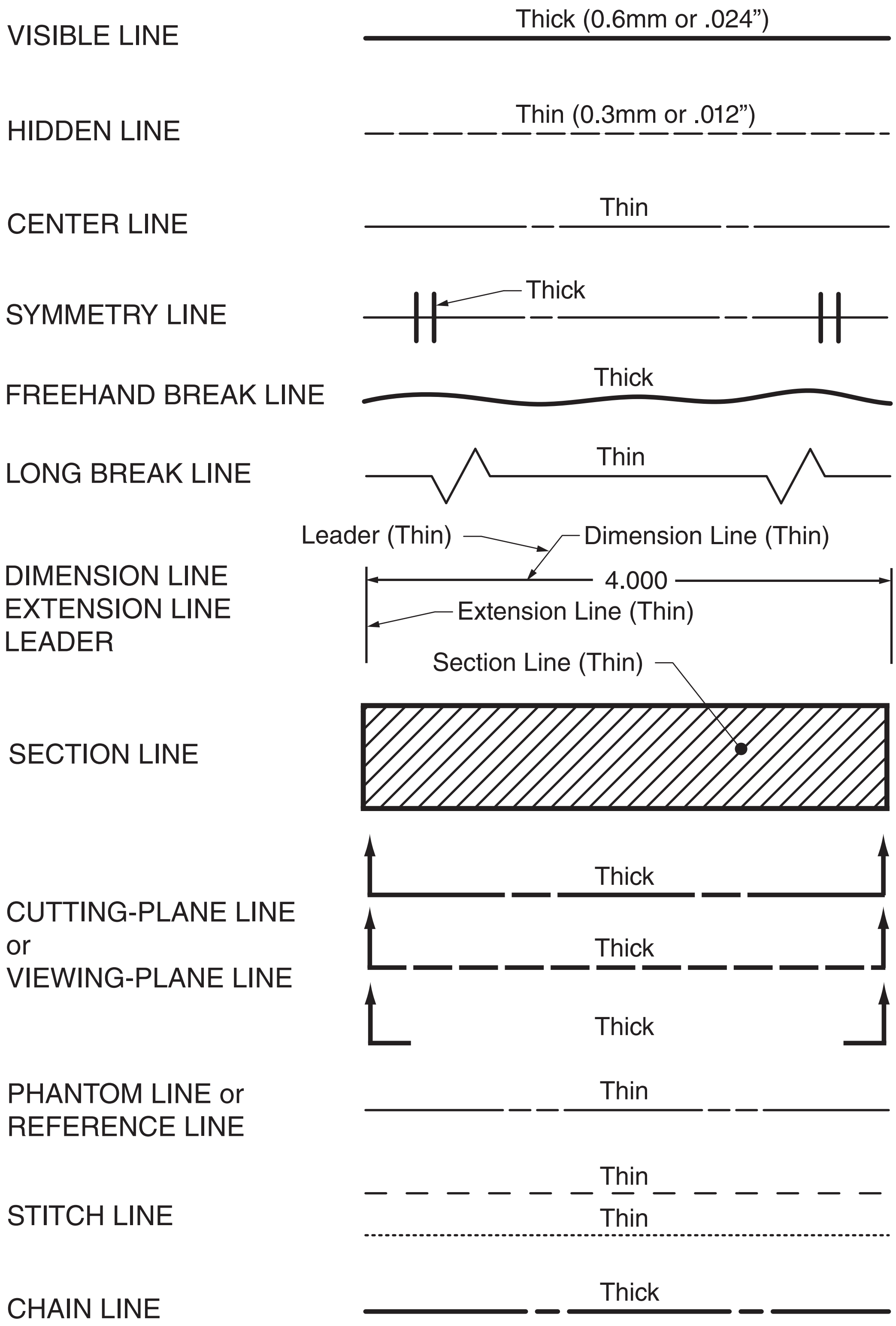
Visible Lines

Visible lines are thick, continuous, bold lines used to indicate all visible edges of an object. They should stand out clearly in contrast to other lines, so that the shape of an object is quickly apparent to the eye.

Hidden Lines

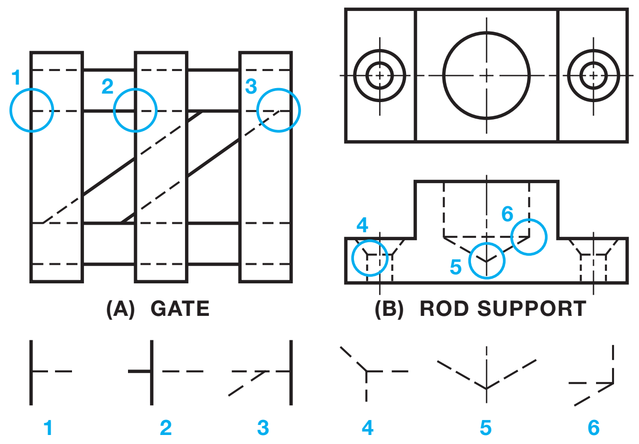
Hidden lines are used to describe features that cannot be seen. They are positioned on the view in the same manner as visible lines. These lines consist of short, evenly spaced thin dashes and spaces. The dashes are three to four times as long as the spaces.

FIGURE 1–3 Alphabet of lines.



These lines should begin and end with a dash in contact with the line in which they start and end, except when such a dash would form a continuation of a visible line. Dashes should join at corners. Figure 1–4 shows examples of hidden line applications. Exceptions for these standards are permitted when the views of a part are automatically generated by a CAD system.

FIGURE 1–4 Hidden lines.



Center Lines

Due to tooling and manufacturing requirements, circular, cylindrical, and symmetrical parts, including holes, must have their centers located. A special line, referred to as a *center line,* is used to locate these features. A center line is drawn as a thin, broken line of long and short dashes, spaced alternately, as shown in Figure 1–5. The long and short dashes may vary in length, depending on the size of the drawing. Center lines may be used to indicate center points, axes (singular, *axis*) of cylindrical parts, and axes of symmetrically shaped surfaces or parts. Solid center lines are often used on small holes (Figure 1–5, Example 1), but the broken line is preferred (Example 2). Center lines should project for a short distance beyond the outline of the part or feature to which they refer. They may be lengthened (extended) for use as extension lines for dimensioning purposes. In this case, the extended portion is not broken, as shown in Figure 1–5, Example 1.

Break Lines

Break lines serve many purposes. For example, they are used to shorten the view of long uniform sections, which saves valuable drawing space, Figure 1–6(A).

FIGURE 1–6 The use of break lines.

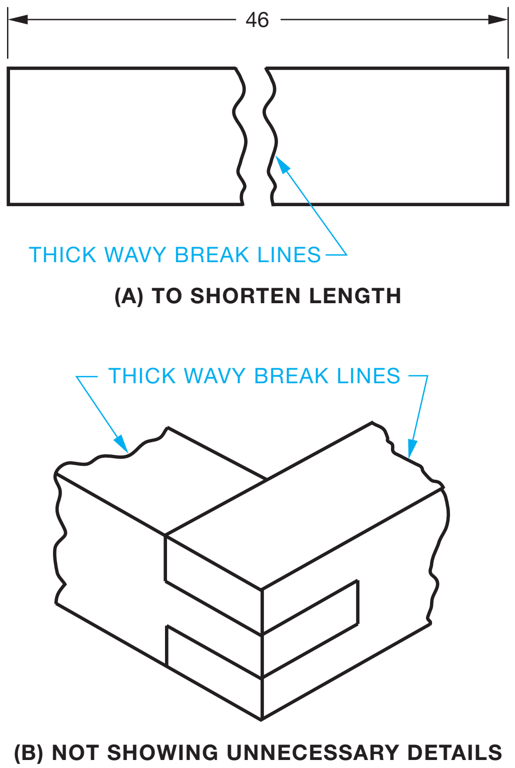
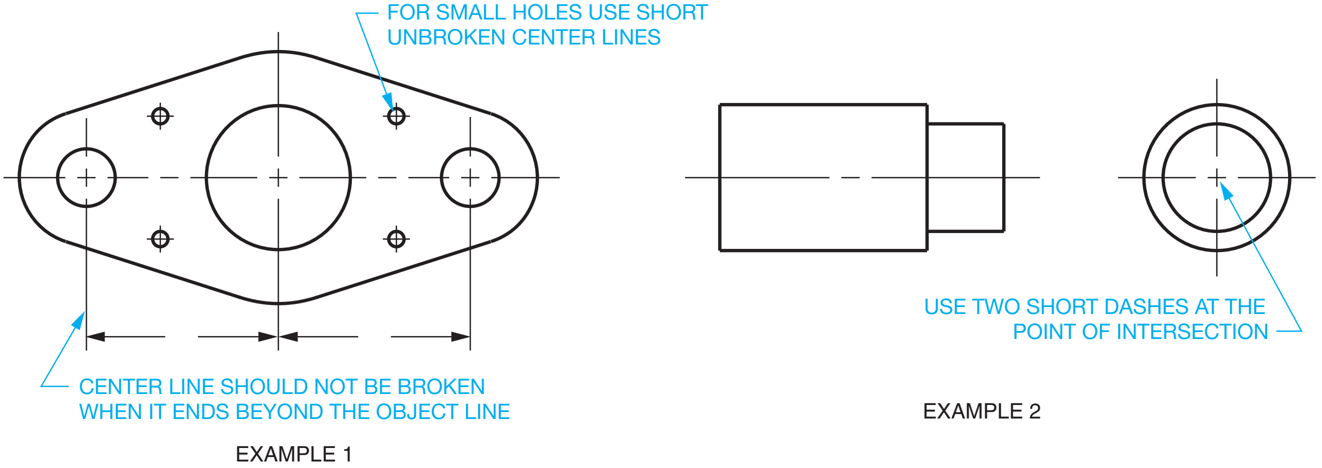


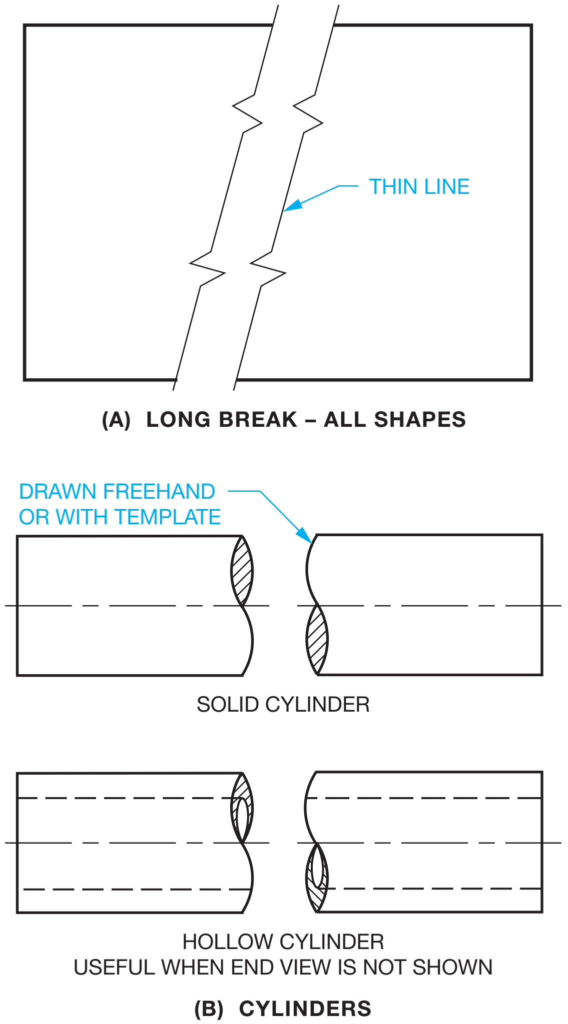
FIGURE 1–5 Center line application.



They are also used to remove a segment of a part that serves no useful purpose on the drawing, thus saving valuable drawing or sketching time, Figure 1–6(B). The break line shown in this figure is one of several break line styles used on engineering drawings. This particular type of break line is shown as a thick, solid line because it forms part of the outline of the object being drawn. It is the third line style used to show the outline of a part.

Another type of break line, as shown in Figure 1–7, is used to shorten the view of long uniform sections. These types of break lines are also used when only a partial view is required. Such lines are used on both detail and assembly drawings. The thin line with freehand zigzags is recommended for long breaks, and the jagged line for wood parts. The special breaks shown for cylindrical and tubular parts are useful when an end view is not shown; otherwise, the thick break line is adequate.

FIGURE 1–7 Conventional break lines.



Line and Space Lengths

There are several things to consider when determining the lengths of lines and spaces for center lines, hidden lines, and other lines with dashes. The size and scale of the drawing will influence the lengths and spaces needed. On larger drawings (e.g., 34" × 44") it might be more appropriate to have slightly longer lines and dashes than on 8.5" × 11" drawings. It is important to maintain the proportions such as the 3:1 ratio for hidden lines. Some CAD programs will allow you to control this through a line type scaling command.

Symbols and Abbreviations

Symbols and abbreviations are extensively used on engineering drawings. They reduce drawing time and save valuable drawing space. The symbols are truly a universal language, as their meanings are understood in all countries. The first abbreviations and symbols that you will see on the drawings in this text are:

IN., meaning *inch*

mm, meaning *millimeter*

FT, meaning *foot*

Ø, meaning *diameter*

R, me aning *radius*

SKETCHING

Sketching is the simplest form of drawing. It is one of the quickest ways to express ideas. The drafter, technician, or engineer may use sketches to help simplify and explain (communicate) thoughts and concepts to other people. Sketching, therefore, is an important and effective method of communication.

Sketching is also a part of drafting and design because the drafter frequently sketches ideas and designs prior to making the final drawing using computer-aided drafting (CAD). Sketching is also used by designers and engineers during the ideation and brainstorming processes. Practice in sketching helps develop a good sense of proportion and accuracy of observation. It is also effective in resolving problems in the early stages of the design process.

CAD has replaced board drafting because of its speed, versatility, and economy. Sketching, like drafting, is also changing, and cost-saving methods are being used to produce a sketch. For example, grid-type sketching paper is used to reduce sketching time and to produce a neater and more accurate sketch. This is because grid-type sketching paper has a built-in ruler for measuring distance and lines act as a straightedge when lines are drawn.

Not all of the drawing needs to be drawn freehand, if faster methods can be used. For example, long lines can be drawn faster and more accurately when a straightedge is used. Large circles and arcs may be drawn or positioned by using a compass. Small circles and arcs may be drawn with the aid of a circle template.

Materials for Sketching

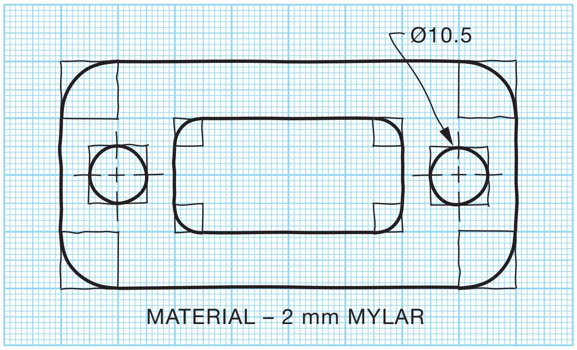
Sketching has two main advantages over formal drawing. First, only a few materials and instruments are required to produce a sketch. Second, you can produce a sketch anywhere. If many sketches are to be made, such as when working from this text, the sketching materials described next should be considered.

SKETCHING PAPER

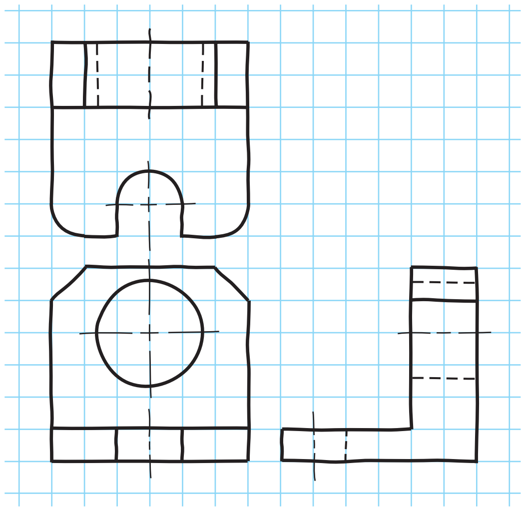
This type of paper has light, thin lines, and the sketch is made directly on the paper. Various grid sizes (spacings) and formats are available to suit most drawing requirements. The two basic types of sketching paper are two-dimensional and three-dimensional sketching paper.

Two-Dimensional Sketching Paper. This type of sketching paper is primarily used for drawing one-view sketches and orthographic views, which are covered in this unit and in Unit 4. The paper has uniformly spaced horizontal and vertical lines that form squares. These are available in a variety of grid sizes, Figure 1–8. The most commonly used spaces or grids are the decimal-inch, fractional-inch, and centimeter. These spaces are further subdivided into smaller spaces, such as eighths or tenths of one inch or 1 mm. Because the units of measure are not shown on these sheets, the spaces can represent any desired unit of length.

FIGURE 1–8 Two-dimensional sketching paper.



(A) ONE-VIEW SKETCH ON DECIMAL-INCH (.01 INCH DIVISIONS) SKETCHING PAPER

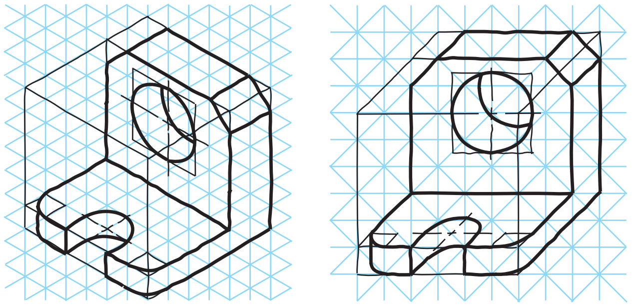


(B) ORTHOGRAPHIC SKETCH ON .25 INCH DIVISION SKETCHING PAPER

Three-Dimensional Sketching Paper. Three-dimensional sketching paper is designed for sketching pictorial drawings. There are three basic types: isometric, oblique, and perspective, Figure 1–9.

Isometric sketching paper has evenly spaced lines running in three directions. Isometric sketching is covered in Unit 7.

FIGURE 1–9 Three-dimensional sketching paper.



Oblique sketching paper is similar to two-dimensional sketching paper except that 45° lines that pass through the intersecting horizontal and vertical lines are added in one or both directions. Oblique sketching is covered in Unit 7.

One-, two-, and three-point perspective sketching papers are designed with worm's- and bird's-eye views. The spaces on the receding axes are proportionately shortened to create a perspective illusion. The sketches made on this type of paper provide a more realistic view than the sketches made on the isometric and oblique sketching papers.

PENCILS AND ERASERS

Soft lead pencils (grades F, H, or HB), properly sharpened, are the best for sketching. Erasers that are good for soft leads, such as a plastic eraser or a kneaded-rubber eraser, are most commonly used.

TRIGONOMETRY SET

This small, compact math set includes a compass, plastic ruler, and triangles. These drawing tools are very useful for sketching.

TEMPLATES

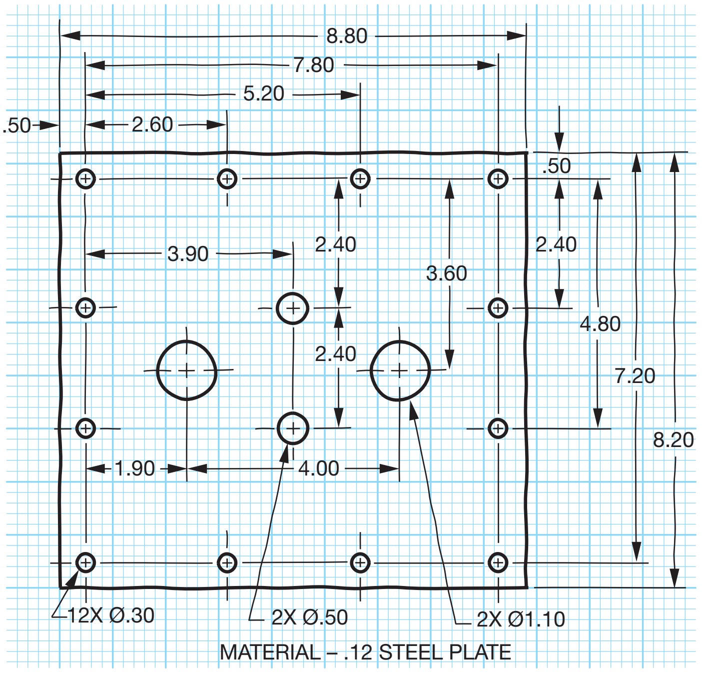
A circle template will improve the quality of your sketches by making circles and arcs neat and uniform. It will also reduce sketching time. Elliptical circle templates, which are used for pictorial sketching, are normally made available in the drafting classroom for use by students.

Sketching Techniques

With reference to Figure 1–10, the following sketching techniques were used:

- A 1-inch grid subdivided into tenths was selected for the part to be sketched. It required

FIGURE 1–10 Sketch of a cover plate.



decimal-inch dimensioning. The part was sketched to half scale (half size). This type of sketching paper simplified the measuring of sizes and spacing and ensured accuracy when parallel and vertical lines were drawn. The grid lines also acted as guidelines for the lettering of notes and helped produce neat, legible lettering.

- A straightedge was used for drawing long lines. This method of drawing lines was faster and more accurate than if the lines were drawn freehand.
- A circle template was used for drawing the circular holes. Freehand sketching of round holes is time-consuming and is not accurate or pleasing to the eye.

INFORMATION SHOWN ON ASSIGNMENT DRAWINGS

Assignment problems are either in inch units of measurement or in millimeters (metric). Metric assignments are distinguishable by the letter M shown after the assignment number located at the bottom right-hand corner of the assignment sheet. Circled numbers and letters shown in color are used only to identify lines, distances, and surfaces so that questions may be asked about these features, as shown on Assignment A-14. For purposes of clarity, the actual working drawing is shown in black. The information shown in color is for instructional purposes only and would not appear on working drawings found in industry.

REFERENCES

ASME Y14.2-2008 Line Conventions and Lettering
ASME Y14.38-2007 Abbreviations and Acronyms

INTERNET RESOURCES

Wikipedia, the Free Encyclopedia. For information on engineering drawings and various line types, see: http://en.wikipedia.org/wiki/Engineering_drawing