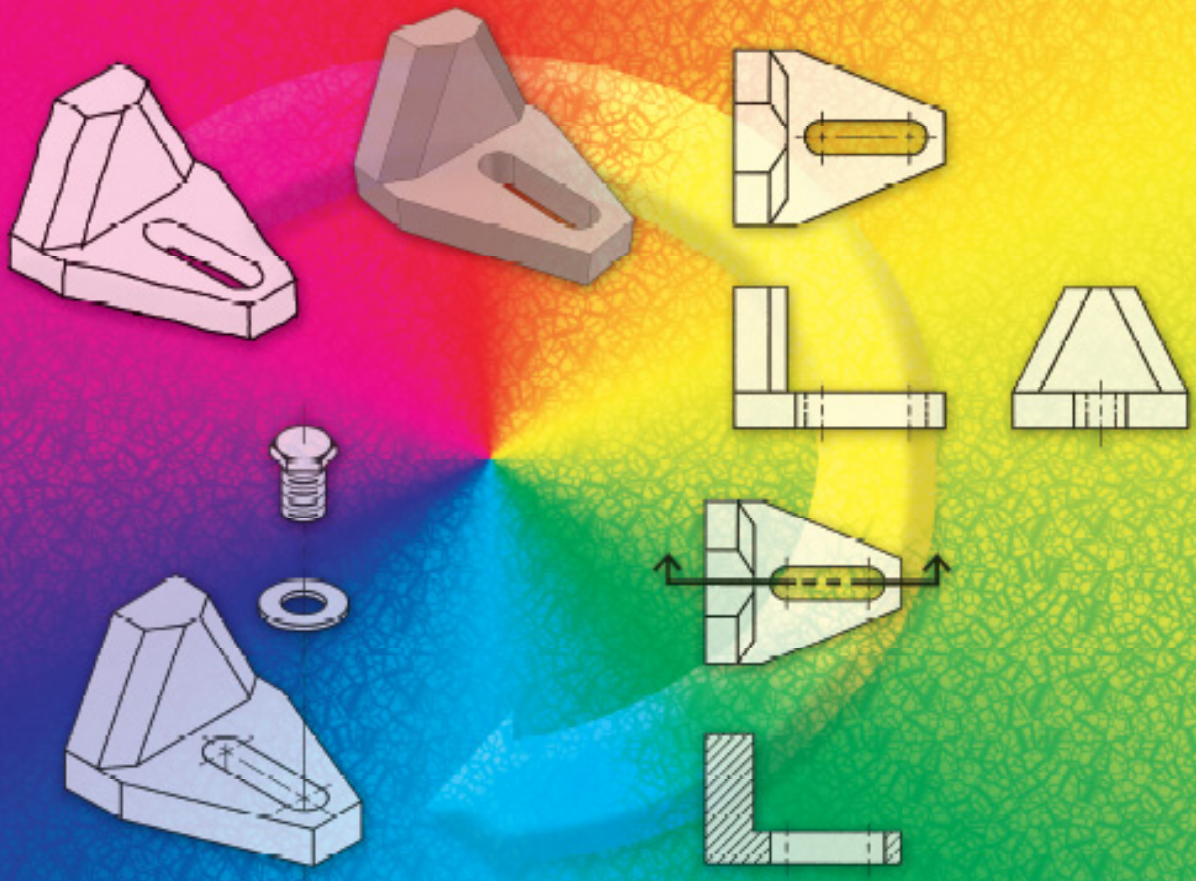
TECHNICAL GRAPHICS



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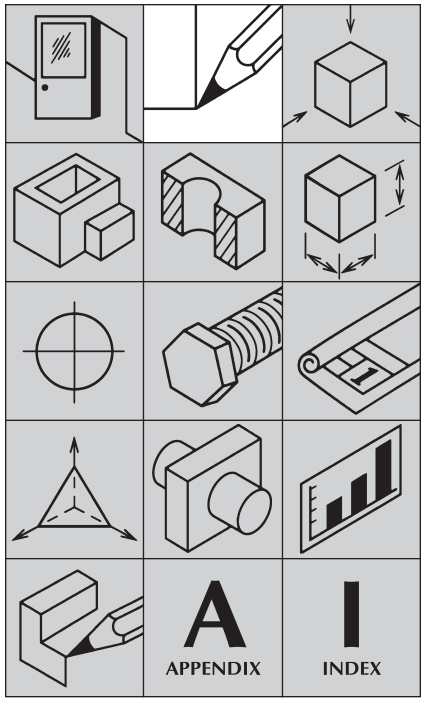


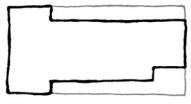
2

TECHNICAL SKETCHING

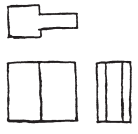
TERMS YOU WILL SEE IN THIS CHAPTER

"BOXING" Process of making marks on established center lines to act as guides when sketching circles or arcs.

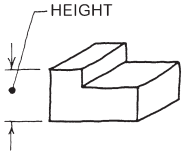
IRREGULAR CURVE Curve that is not a function of a radius.



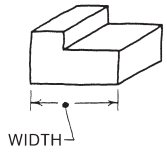
CONSTRUCTION LINES Very light lines used as guides when sketching. If drawn correctly, they will be so light that the darkened final sketch lines will render the construction lines nearly invisible.



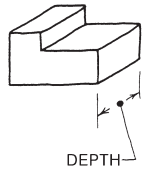
ORTHOGRAPHIC PROJECTION SKETCH Sketch made in orthographic projection; that is, a sketch where the direction of sight is perpendicular to the principal plane of projection. Most often, the top, front, and right side views are shown.



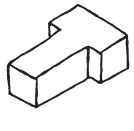
HEIGHT Size of an object measured from top to bottom.



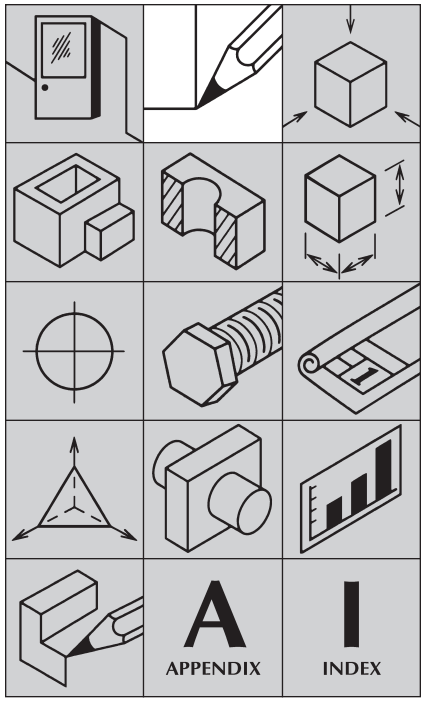
WIDTH Size of an object measured from side to side.



DEPTH Size of an object measured from front to back.



ISOMETRIC PICTORIAL SKETCH Sketch drawn as an isometric drawing; that is, the height axis is vertical, but the width and depth axes are drawn 30° from the horizontal. This produces an easy-to-read pictorial view.



2

TECHNICAL SKETCHING

2.1 *INTRODUCTION*

The graphic language of the engineering world is used to communicate ideas and concepts through a series of pictures and symbols. After these ideas, concepts, and details for a project have been finalized, precise technical drawings are produced, using a CAD program so that parts may be manufactured. CAD drawings are usually generated from sketches made during the project-planning stage.

The objective of sketching is to make a quick, graphic representation of an idea that can be easily communicated to a coworker, a designer, an engineer, or a client. (A sketch is generally made without the aid or use of technical drawing instruments.) The primary use of a sketch is to represent what is seen rather than to give technical information. Sketches are an integral part of analytical calculations insofar as they "define" the physical objects being analyzed. For this reason, sketches show an object as it appears, with little emphasis on hidden or internal surfaces or features, although they may be included if necessary (Figure 2.1). The sketch also serves as an *immediate* graphic communication, often drawn under varying conditions such as on the job site or in a business meeting.

Sketching, similar to writing, is a skill that can be developed through practice. This chapter will show you how to sketch effectively. It will also show you engineering applications of your sketches. Techniques and suggestions will be given so your sketches will look more realistic. You can practice sketching anywhere and at any time because the only items needed to make a sketch include a writing instrument, a drawing surface, and possibly an eraser.

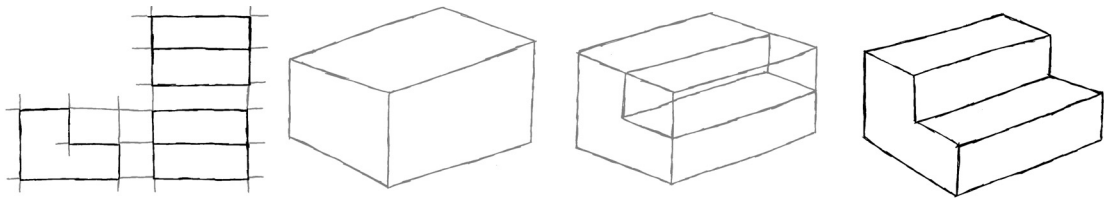


Figure 2.1 Sample of four steps for making a sketch

Because sketching generally precedes the action of creating a drawing on a computer, this chapter offers you sketching techniques with only brief explanations concerning drawing theory. A detailed theory of projections is discussed in Chapter 3.

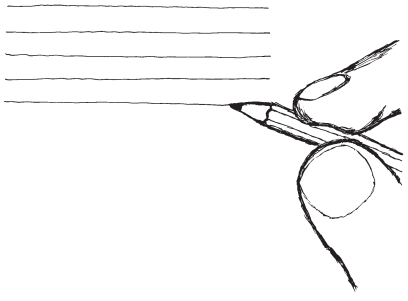


Figure 2.2 Sketching parallel horizontal lines

2.2 *SKETCHING HORIZONTAL LINES*

Lines commonly used for sketches include straight lines and curved lines. Straight lines can be divided into horizontal, vertical, or inclined lines. The normal way to draw parallel horizontal lines is from left to right for right-handed people or right to left for left-handed people. You should be able to develop enough skill to draw many evenly spaced horizontal lines with uniform spaces between the lines (Figure 2.2).

Care should be used to avoid drawing arcs instead of horizontal lines. Arcs occur when the elbow remains stationary. You must move your entire arm when drawing horizontal lines. This is particularly important when sketching long horizontal lines. Long lines may be sketched more accurately by instead sketching a series of short horizontal lines end to end. An important tip is to put the pencil on the starting point and to look at and draw to the finishing point.

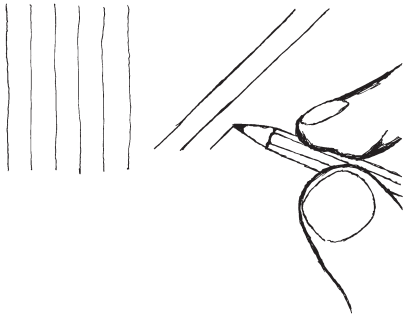


Figure 2.3 Sketching vertical and angular lines

2.3 *SKETCHING VERTICAL LINES*

Vertical lines are usually drawn from top to bottom. Rotate your paper to a position where it is comfortable to sketch these lines You should be able to develop enough skill to draw uniformly spaced parallel vertical lines.

2.4 *SKETCHING ANGULAR LINES*

Angular lines are drawn from lower left to upper right. This is a comfortable position for the right-handed person. The most uncomfortable and difficult lines to sketch are angular lines extending from upper left to lower right. Again, rotate the paper to a position where it is comfortable to sketch these lines (Figure 2.3).

2.5 *SKETCHING CURVED LINES*

Curved lines are identified as circles, arcs, or irregular curves. Circles are sketched most accurately by first sketching center lines. The radius is then marked on these center lines as

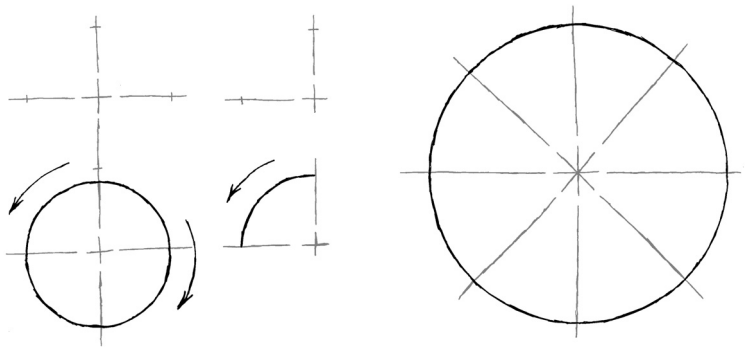


Figure 2.4 Guide marks for circles and arcs

guides. These marks form a box within which the circle can easily be sketched—a process often called **"boxing"** a figure. Lastly, the circle is sketched in two motions. First, the left side of the circle is sketched in a counterclockwise direction, and then the right side of the circle is sketched in a clockwise direction (Figure 2.4).

Large circles may require a second set of center lines rotated at a 45° angle in order to increase the number of guides from four to eight. Also, four arcs may be required. If so, the paper should be rotated for completion of the last two quadrants.

Arcs are sketched similarly to circles. The orientation of the arc and the size of the arc will govern how you sketch the arc. For medium and large arcs, it is recommended that center lines and guides be drawn.

Irregular curves (those without a given radius) should be sketched using pencil strokes that are most comfortable for you. Very light lines should be sketched first to check for the correct shape. Draw dark lines over the light lines to complete the curve. An example of an irregular curve is shown in Figure 2.5.

Figure 2.5 Sketching an irregular curve

2.6 *DRAWING MEDIA*

After becoming familiar with the most comfortable sketching strokes, identify an appropriate medium for the sketch. Drawing media are the materials upon which you will make your sketch. We all know that sketches are made on everything from matchbook covers to expensive papers or films. However, the interest here is to identify those paper or film materials that are commonly used in the engineering field.

Technical sketches are most often made on $8\frac{1}{2} \times 11$-in. opaque paper. For copying purposes, the original sketch is referred to as the master. Other paper sizes include $8\frac{1}{2} \times 14$ in. or even 11×17 in., depending on the size of the sketch.

2.7 *GRIDS FOR SKETCHING*

Some paper may be printed with a grid of thin, lightly colored lines, which are a significant aid to the person doing the sketching. Common grid patterns are square or isometric (Figure 2.6).

A special printed grid is the "dropout" grid. This consists of a light blue grid printed on translucent paper. The grid serves as a

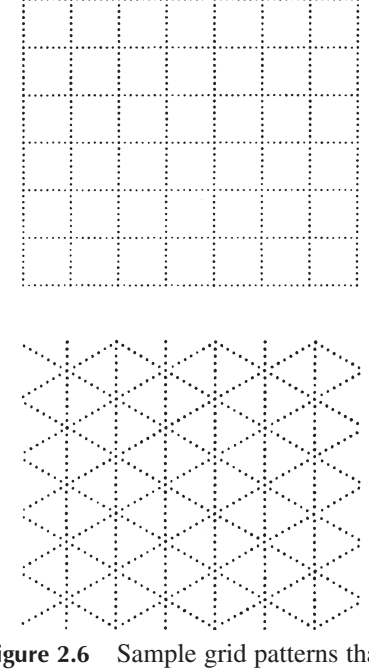


Figure 2.6 Sample grid patterns that are useful for making refined sketches

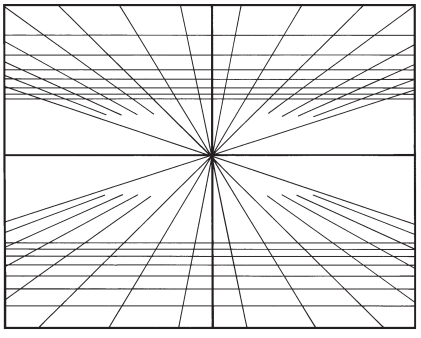


Figure 2.7 Grid patterns are used to make more accurate perspective sketches.

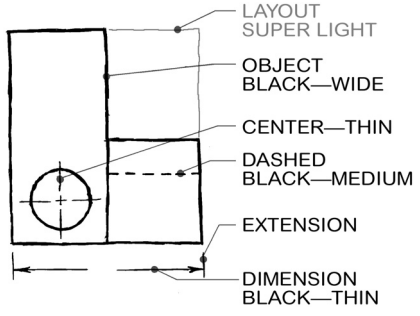


Figure 2.8 Line weight conventions used for finished drawings are also used for sketching.

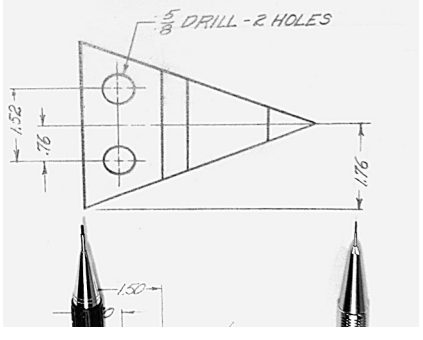


Figure 2.9 Fine-line pencils are manufactured in different sizes to produce given line widths.

guide to the person sketching, but when copies are made, the grid will not appear and the sketch stands by itself. This is a great aid to making better sketches. Other special large-printed grids are available for a variety of patterns, such as perspective grids for interior or exterior views at various angles (Figure 2.7).

2.8 *LINE WEIGHTS*

Line weight refers to the line blackness or thickness. The very light lines used to sketch for size, proportion, and position are called layout lines, or **construction lines**. They are so light that they do not appear if copied using a standard copy process. Construction lines are the first lines drawn. After the shape of the object has been sketched, the lines are refined. Then the visible lines are darkened with black solid lines. Hidden lines represent nonvisible edges or surfaces and are drawn with black dashed lines. If the original construction lines are drawn light enough, none should have to be erased after the sketch has been darkened and refined.

Remember that all the final lines should be dark enough so they are clear and copy well. The thickness of the lines on detail sketches should follow the accepted conventions for line widths. This means the object lines will be the widest; hidden lines will be of medium width; and lines such as center lines, dimension lines, extension lines, and so on, will be thin (Figure 2.8).

2.9 *SKETCHING INSTRUMENTS*

Sketches are generally made with black lines from a lead pencil. The common wood pencil has a number 2 lead, which may be used to draw the layout lines simply by allowing the weight of the pencil to pass over the paper. Then during the darkening process, the pencil must be pushed harder against the paper to gain the proper blackness of the final sketch.

As you learned in Chapter 1, fine-line mechanical pencils are used in technical graphics. The 0.3-mm fine-line pencil may be used for the construction lines, and a 0.5- or 0.9-mm pencil may be used to make the dark refined lines. Fine-line pencils take the width of the diameter of the lead (Figure 2.9).

Colored pencils are not commonly used for sketching. One reason for not using colored pencils is that the purpose of the sketch is to quickly convey information, not to make a finished illustration. However, if color is important for communication, such as for comments or corrections, colored pencils could be used on analytical sketches created by the designer.

2.10 *ENLARGING AND REDUCING USING A GRID*

Several methods may be used to enlarge or reduce the size of a sketched image. One of the easiest methods of increasing or decreasing the size of the image, especially if the original was made on a grid, is to construct a larger or smaller grid and simply plot enough points to reconstruct the original image (Figure 2.10).

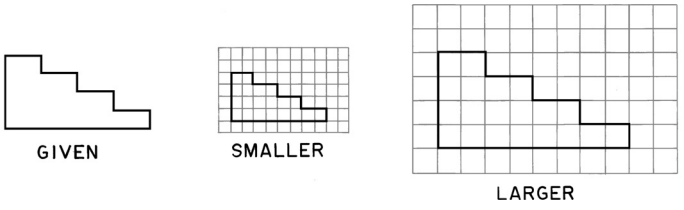


Figure 2.10 A given image presented on a grid may be enlarged or reduced simply by altering the size of the grid.

2.11 *ENLARGING AND REDUCING USING A RECTANGULAR DIAGONAL*

The rectangular diagonal is another useful aid for sketching. If an extended diagonal is drawn across opposite corners of a given rectangle, a proportionally larger or smaller rectangle can easily be constructed (Figure 2.11).

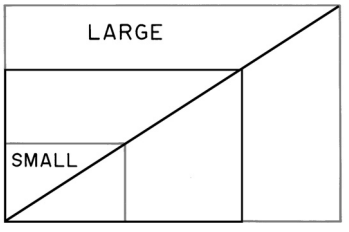


Figure 2.11 A rectangle may be enlarged or reduced by drawing a diagonal line through the opposite corners of the given rectangle.

2.12 *ENLARGING AND REDUCING BY CHANGING THE FOCAL DISTANCE FROM THE OBJECT TO THE PLANE*

If you are sketching large buildings from a distance, many proportions may be transferred to the sketch by holding your pencil at arm's length from the eye. This will help estimate the proportion of heights of buildings, bridges, or other similar large objects (Figure 2.121). The greater the focal distance between the object and the picture plane (in this case, your pencil at arm's length), the shorter the object's height will appear on the picture plane (Figure 2.13).

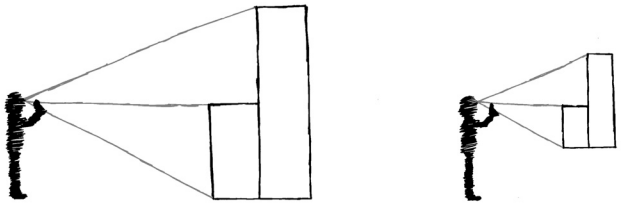


Figure 2.12 A large object may be proportionately reduced by holding a pencil at arm's length and sketching the shortened heights accordingly.

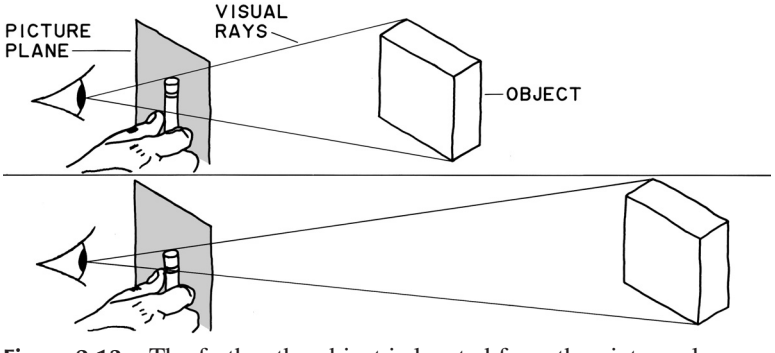


Figure 2.13 The farther the object is located from the picture plane, the shorter its height will appear on the picture plane.

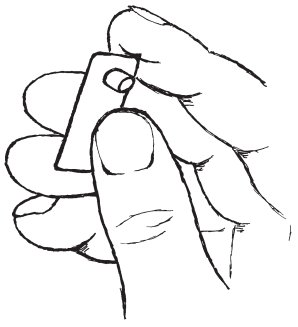


Figure 2.14 The relative proportion of small objects may be represented by showing them with a hand.

2.13 *SKETCHING SMALL OBJECTS WITH A HAND FOR PROPORTION*

A very common sketching technique employed when showing small objects is to show them in relation to a hand. For instance, an object pictured by itself may not be representative of its actual size. However, the association of size may easily be illustrated by showing a hand holding the object (Figure 2.14). Other familiar objects may be used in place of a hand, such as a pencil or a scale. For large objects, such as tractors or buildings, it may be helpful to sketch a human figure next to the object to indicate proportion (Figure 2.15).

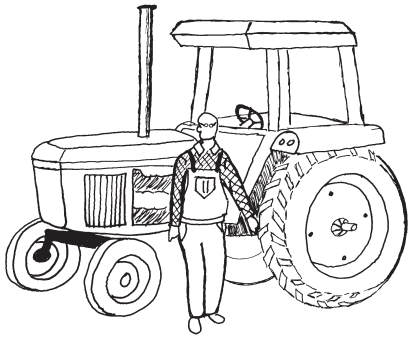


Figure 2.15 The proportion of large objects may be represented by showing them with a person.

2.14 *SKETCHING SOLIDS*

You must learn to sketch two- and three-dimensional shapes accurately. One approach to sketching a manufactured product is to assume that all the components making up the assembly are simply a collection of outlines of various basic shapes. These shapes may include cubes, rectangular solids, cylinders, cones, and pyramids.

The major concern when drawing cubes or rectangular solids is that the sides must appear parallel in the sketch (vertical lines are always vertical even though the angular lines may vary) (Figure 2.16). The cylinder also requires lines to be drawn parallel to each other. This is most easily accomplished by sketching layout lines that define the two elliptical ends of the cylinder, and then connecting the end surfaces (Figure 2.17). For the cone and pyramid, the center lines of the base should be sketched first, then the base and altitude, and lastly the sides (Figure 2.18). Using these sketching layout procedures, it is easy to sketch such objects as a sander and drill press (Figures 2.19–2.21).

A good exercise to improve sketching techniques is to sketch basic shapes over and over until you are comfortable with the steps involved in the process. You will also develop speed through this practice.

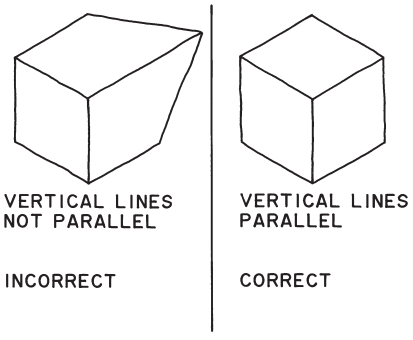


Figure 2.16 All vertical lines must be parallel or a distorted view will result.

2.15 *FOUR STEPS TO SKETCHING AN OBJECT*

There are four major steps to follow when making a sketch of most objects or manufactured products (Figure 2.20). The first step is to *block out the outline* of the object or assembly to be sketched with light construction lines. This includes orienting the view. For instance, you may outline the object in isometric or perspective before drawing a detailed sketch. Proper orientation is

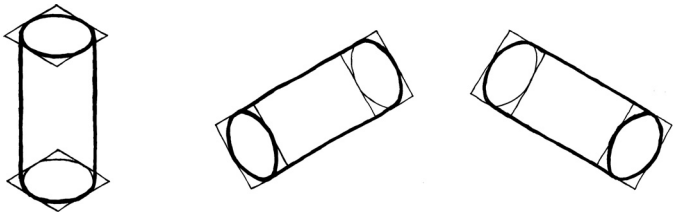


Figure 2.17 Define the ends of the cylinder, and then connect the ellipses with parallel lines to complete the cylinder.

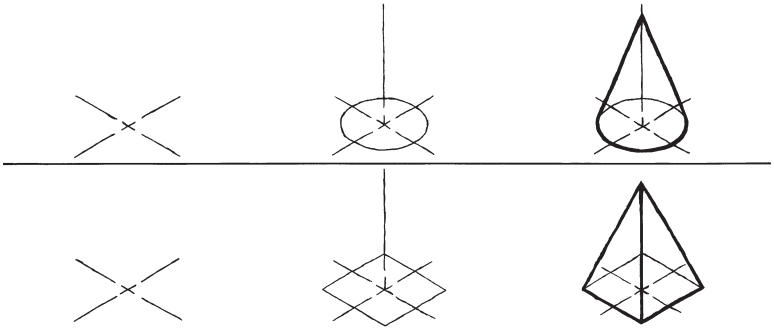


Figure 2.18 When sketching a cone or pyramid, first construct center lines, then base and altitude lines, and finally the sides of the cone or pyramid.

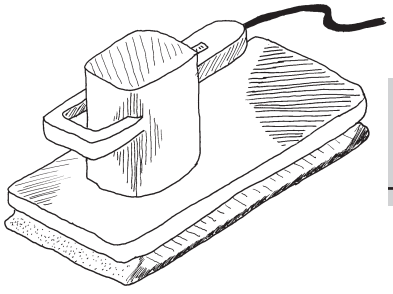


Figure 2.19 Simple sketch of electric sander

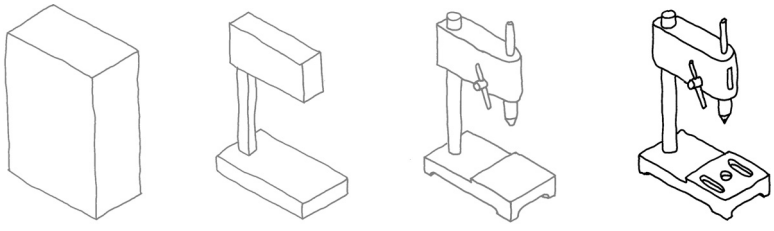


Figure 2.20 Making a sketch: (1) block out outline, (2) block out major features, (3) refine shapes, and (4) add details and darken.

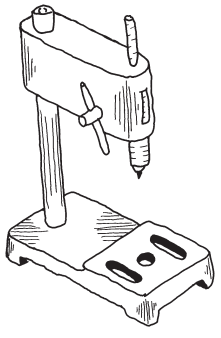


Figure 2.21 Sketch of drill press with shading

very important in order to show the most descriptive view of the object in the front view.

The second step when sketching a product is to *block out the major features* of the product. This is generally accomplished by sketching light construction lines to outline the major shapes in the form of solids (cubes, rectangular solids, cylinders, cones, or pyramids) or variations of these and other solid shapes.

The third step is to *refine the shapes* already sketched. This step takes into account particular details such as rounded edges, sharp edges, finished and cast surfaces, and so on.

The fourth and last step is to *darken* only the layout lines you want to appear in the final sketch. This should be done with black lines, in accordance with the accepted line widths.

After a sketch has been made using some of the proportional techniques discussed, additional information in the form of dimensions or notes may be added (Figure 2.22).

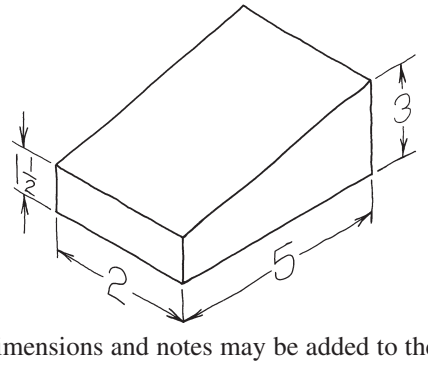


Figure 2.22 Dimensions and notes may be added to the sketch.

2.16 *BASIC SHADING OF SOLIDS*

Shading is the process of indicating surface texture, shape description, or depth by adding certain sketching patterns. Seldom will the drafter take the time to shade various parts being sketched. However, if basic shading is necessary, the rectangular shapes should be shaded showing a light, medium, and dark surface. A cylinder will be darker on the upper and lower edges of the length of the axis view. A similar treatment is applied to cones, except the shading gets narrower toward the point. On a pyramid, the two adjacent surfaces should be shown by the contrast between medium and dark shading (Figure 2.23). A suggestion for making the shading look more uniform is to dull the point of the pencil before trying to shade large surfaces. The development of shading technique, like all parts of a sketch, requires practice. Daily observation of objects in sunlight or in artificially lighted areas can aid in this process.

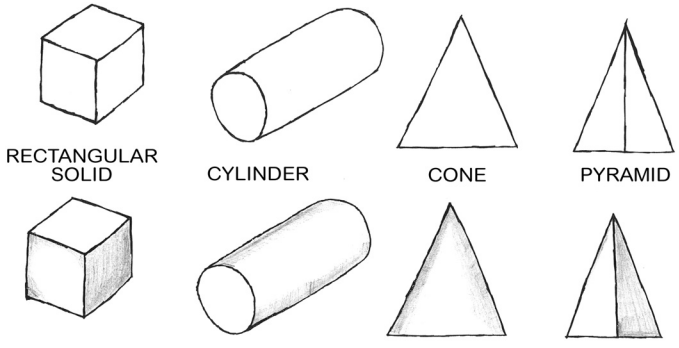


Figure 2.23 Shading techniques applied to basic solids

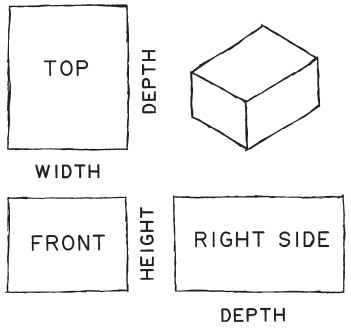


Figure 2.24 Position of commonly shown views in orthographic projection

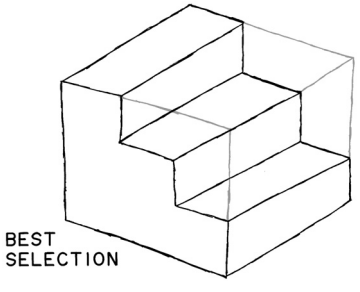


Figure 2.25 It is important to select the best position for the front view.

2.17 *ORTHOGRAPHIC PROJECTION SKETCH*

Sketches made in *orthographic projection* are generally the top, front, and right side views of an object. However, the back, bottom, and left side views may have to be sketched occasionally. In an **orthographic projection sketch,** the front view is the most critical. It should be the most characteristic view of the object. The front view indicates the **height** and **width** dimensions. The right side view is projected at 90° directly to the right of the front view and indicates the height and **depth** of the object. The top view is projected at 90° directly above the front view and indicates the dimensions for width and depth (Figure 2.24).

Before sketching an object's front, top, and right side views, first determine the best direction to view the front view. Then sketch the front view (Figure 2.25).

An orthograpic projection sketch follows all four steps of the sketching process already described. First, outline the extremes of the box, which will include the entire front view, with light layout lines. Then sketch a layout of the major features. Next, sketch a layout of the minor details. Lastly, darken the lines that should remain on the final sketch, remembering to employ the correct line widths. You must develop these lines for all the required views. Both visible and hidden surfaces and edges are represented when sketching orthographic views.

2.18 *ISOMETRIC PICTORIAL SKETCH*

The most common pictorial view to sketch is an isometric view. An isometric drawing has a vertical axis and two axes at 30° from the horizontal (Figure 2.26). The axes shown are located at the near bottom corner of the object. In an **isometric pictorial sketch,** height dimensions are sketched along or parallel to the vertical axis, and the width and depth dimensions are sketched on or parallel to each of the two 30° angular axes.

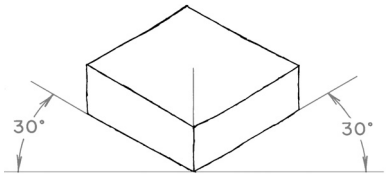


Figure 2.26 Isometric axes are vertical and 30° above horizontal (to left and right).

The center lines for circles drawn in isometric are parallel to one of the three isometric axes. This means the circles will appear as ellipses. Note the orientation of the long and short distances across the ellipses when they are drawn on the three isometric planes (Figure 2.27).

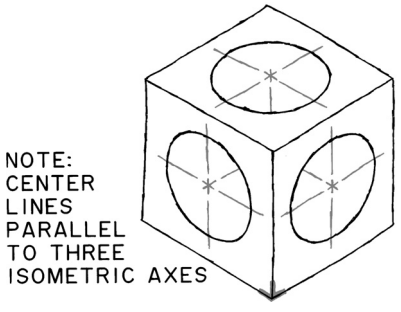


Figure 2.27 When sketching ellipses (circles shown on isometric planes), it is important to have the ellipses oriented correctly. This is done by orienting the center lines for each ellipse parallel to the axes of that isometric surface.

Remember, the four steps still apply when making an isometric pictorial sketch. Sketch the outline box first using the extreme height, width, and depth. Next sketch the major solids and features with layout lines using height, width, and depth. Then add details. Lastly, darken (to black) the lines you want to appear in the final sketch. Only the visible lines are darkened when making an isometric pictorial sketch.

2.19 *OBLIQUE PICTORIAL SKETCH*

An oblique pictorial view shows one of the principal views (front, top, or side view) in the plane of the paper. This means two of the principal dimensions (height and width if the front view is drawn in the plane of the paper) will be sketched on the horizontal and vertical axes. The depth dimension will be sketched on an angular axis slanting away from the viewer at any angle between 15° and 75°. The most frequently used angle is 45° (Figure 2.28).

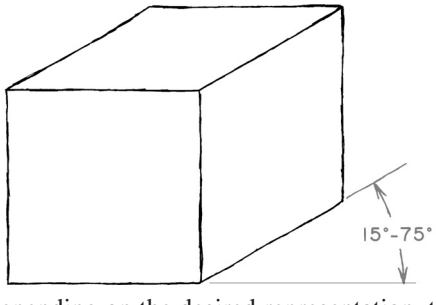


Figure 2.28 Depending on the desired representation, the receding axis of an oblique sketch may vary from 15° to 75°. The most common receding angle for oblique sketching is 45°.

Figure 2.29 Oblique sketch of a desk

When most of the detail is on a single surface, an oblique sketch can be effective, especially if most of the arcs or circles fall on this plane. In this case, the front surface is sketched as a front view; then the depth axis is added at 45°. Examples of objects that could appropriately be sketched in oblique would be a set of kitchen cabinets, a desk, a speedometer, or a gauge (Figures 2.29 and 2.30). When sketching in oblique, the same four steps are applicable. It is common practice to darken only visible lines when sketching

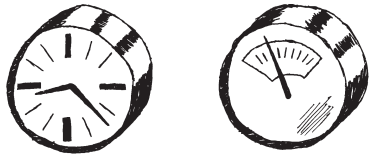


Figure 2.30 Oblique sketches of gauges

oblique pictorials. The oblique sketch may be easier when only rectangular grid paper is available. The normal surface can be sketched accurately, as can any selected receding axis.

2.20 *WHERE DO IDEAS COME FROM THAT REQUIRE SKETCHING?*

There are many reasons for making technical sketches. As you learned earlier, the primary reason is to produce a quick graphic picture of an idea or object to convey to another person or group. From where does the original idea or concept come, however? There are many sources from which you should be able to make a sketch of an object or product.

One source for the original image is your mind. Another source could be a picture or technical drawing—frequent sources in the classroom. A third source is a photograph of the object. Translucent paper can be placed over the surface of the photo in order to make a refined sketch. Alterations can easily be made to the sketch of a photograph. Yet another source is a model or prototype of the object. Using a model as a source requires you to sketch from a three-dimensional object, which means you must visualize and be able to draw what you see.

Figure 2.31 Sketches are often made from verbal information given over the phone.

In production modification sketches, it is recommended that you actually look at the object as you make a sketch of its alterations. You should be able to make a better graphic image if the actual object to be modified is within sight during the sketching process. There may be times when you do not have access to the product or object, however, and you must generate your sketch from a written description. This means you have to visualize the object from its description only, without the aid of any models, photos, or drawings. You should have a thorough understanding of the language of graphic design before attempting a sketch based only on a written description.

Often the information required for a sketch is given by a verbal description. In the real world, engineers and designers receive information over the telephone daily and often have to make sketches representing this information (Figure 2.31). In such situations, ask the customer to briefly describe the entire object to be sketched before you even try to draw a line. This enables you to visualize the general concept of the object. It may be helpful to orient the top, front, left, or right views of the object in your head before putting pencil to paper. Then have the person describe the object by its major components first, followed by its specific details. After you have sketched the item, take the time to describe your sketch back to the originator in order to check that you correctly understood the features required. You also should send or fax a copy of the sketch to your correspondent to ensure that you both are working from the same concept.

There are several descriptions provided at the end of the chapter for practice. These exercises require you to make sketches using many of the methods described in this chapter.

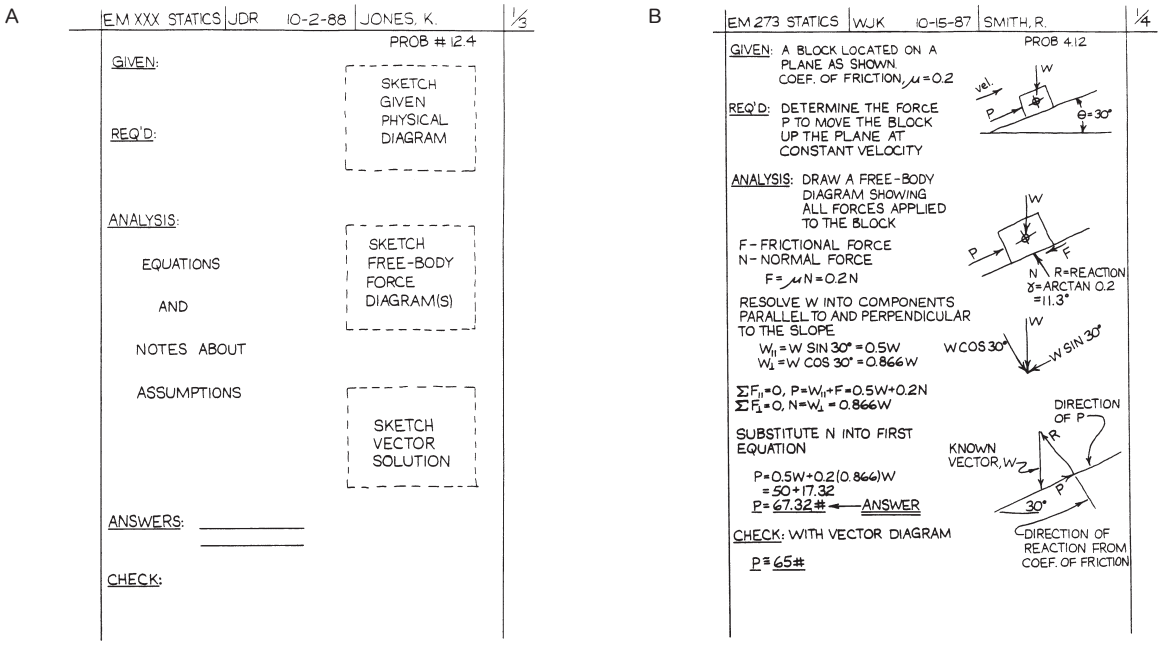


Figure 2.32 (*A*) Common layout used for stating and solving technical problems. (*B*) Example of typical engineering problem.

2.21 *SAMPLE ENGINEERING APPLICATIONS*

A typical engineering problem is shown in Figure 2.32. The problem is sketched on engineering paper, and the information at the top of the page gives the class, the student's name, the date, and the problem number. The problem itself contains sketches, a description of what is required, the analysis with equations, and the solution.

Some examples of analytical sketches are illustrated in Figures 2.33–2.40. These represent the types of sketches you might be asked to produce in industry or on the job site.

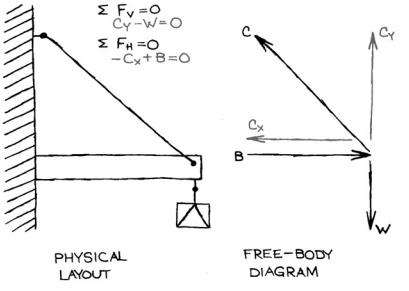


Figure 2.33 Typical sketch for a 2-D statics problem

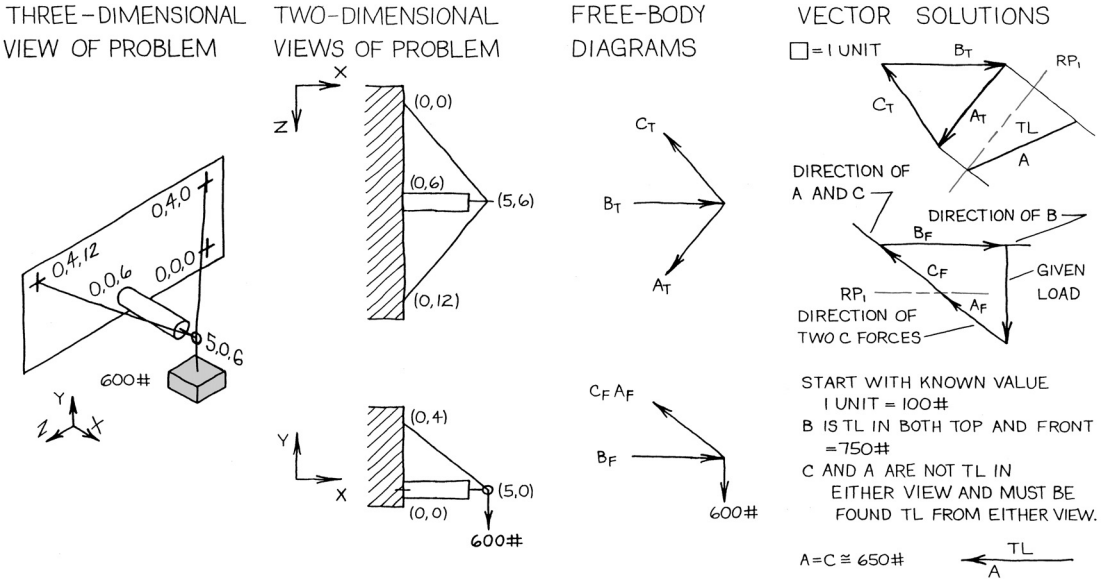


Figure 2.34 Three-dimensional statics problems

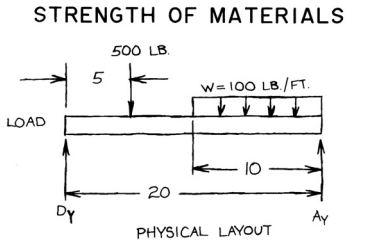


Figure 2.36 Sketch of typical technology application

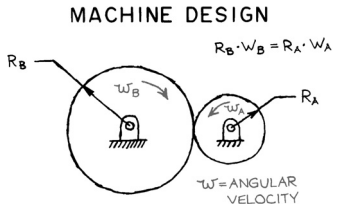


Figure 2.35 Sketch of typical mechanical technology application

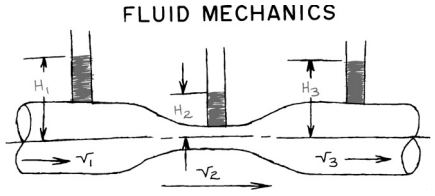


Figure 2.37 Mechanical, chemical or civil engineering technologists might use this type of sketch.

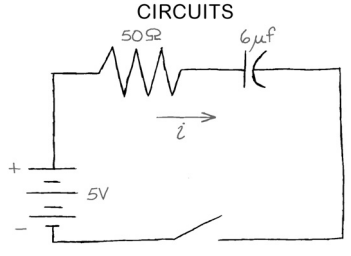


Figure 2.38 Electrical, welding, and industrial engineering technologists often sketch circuits.

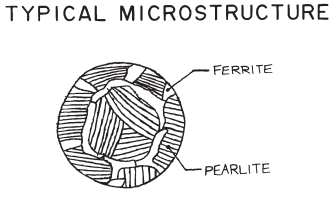


Figure 2.39 Metallurgical engineers sketch microstructures of materials.

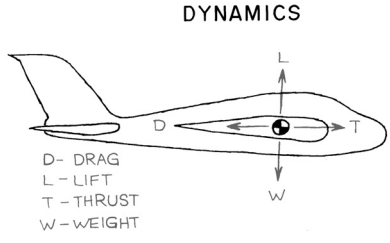


Figure 2.40 Aeronautical engineers typically sketch effects of forces acting on aircraft.

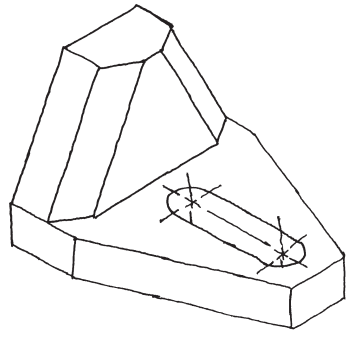


Figure 2.41 Sketch of table saw fixture prior to generating computer images

2.22 *SAMPLE PROBLEM: TABLE SAW FIXTURE*

This textbook will use a common example to apply the principles presented in this chapter through Chapter 12. The common example is a table saw fixture designed for use on a table saw when cutting equal-length pieces. This fixture has a right angle, is strong, and has an elongated hole that will be used when fastening the fixture to the table of the saw. Figure 2.41 is a sketch of the fixture. Figure 2.42 shows how the fixture will be used on the table of the saw.

Illustrations of the table saw fixture will be presented using a variety of CAD packages. Each one will offer a different method for achieving a detailed drawing. You will find these illustrations prior to the summary of each chapter.

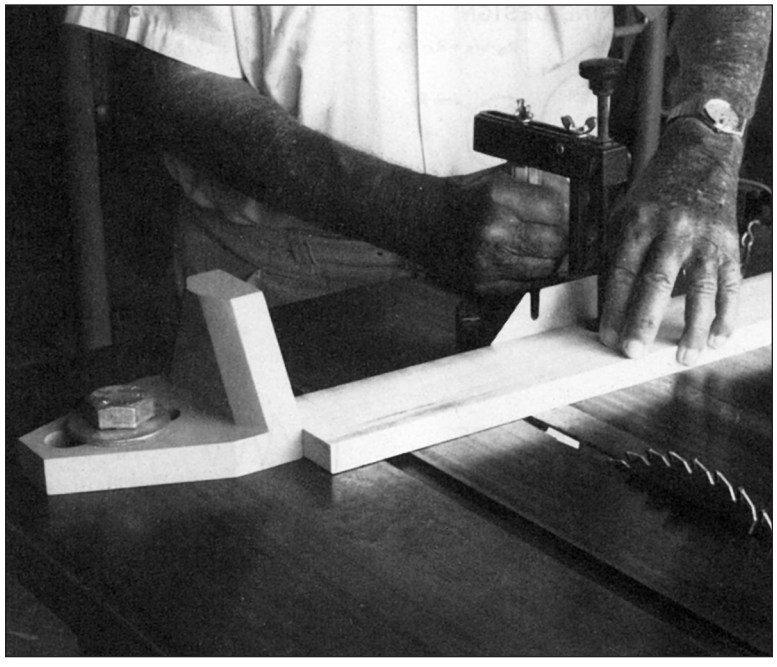


Figure 2.42 Table saw fixture in use

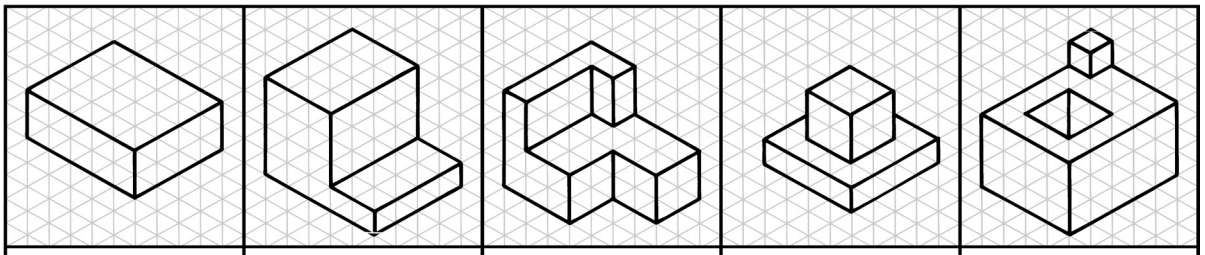
2.23 *SUMMARY*

Sketched images generally show what the viewer visualizes rather than technical details. Often the engineer does not have time to make detailed engineering drawings, so a sketch is created. The sketch is then passed to the designer who will make the technical drawings. Both the engineer and designer must be able to sketch clearly and accurately. In addition, the engineer or designer may be required to sketch in the field, on the job, or in a meeting in order to better communicate ideas or concepts to others. Sketching is an extremely useful skill when used to make quick graphic images to help enhance communication.

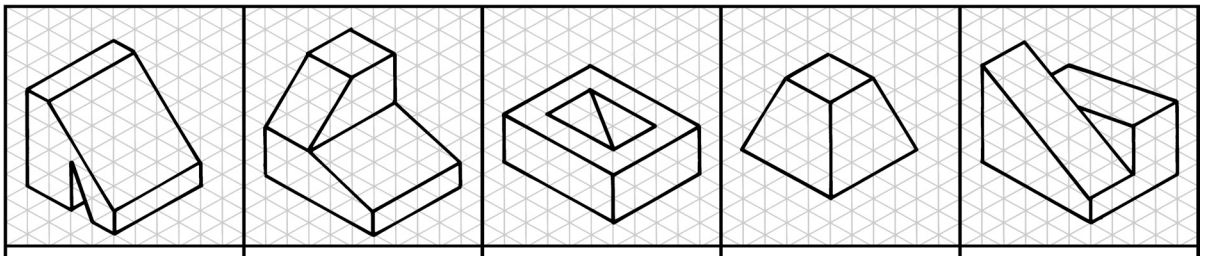
PROBLEMS

Problems 2.1–2.20

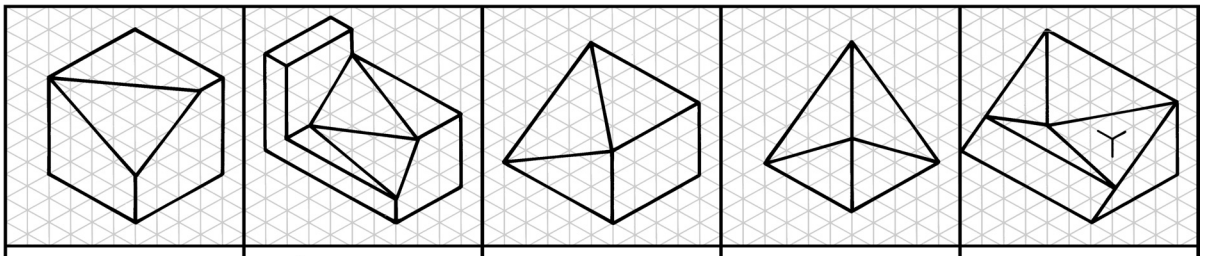
These problems are drawn in isometric on an isometric grid. You are to sketch these objects in orthographic (draw the top, front, and right side views) using $\frac{1}{4}$-in. square grid paper. Each space on the isometric grid equals one square on your grid paper. Leave two spaces between the views. Note: Problems 2.1–2.5 have only normal surfaces, problems 2.6–2.10 also have inclined surfaces, problems 2.11–2.15 have oblique surfaces, and problems 2.16–2.20 have curved surfaces.



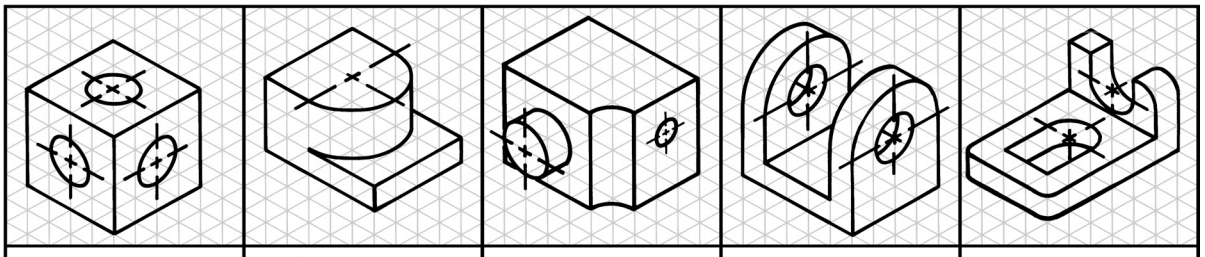
Problem 2.1	Problem 2.2	Problem 2.3	Problem 2.4	Problem 2.5



Problem 2.6	Problem 2.7	Problem 2.8	Problem 2.9	Problem 2.10

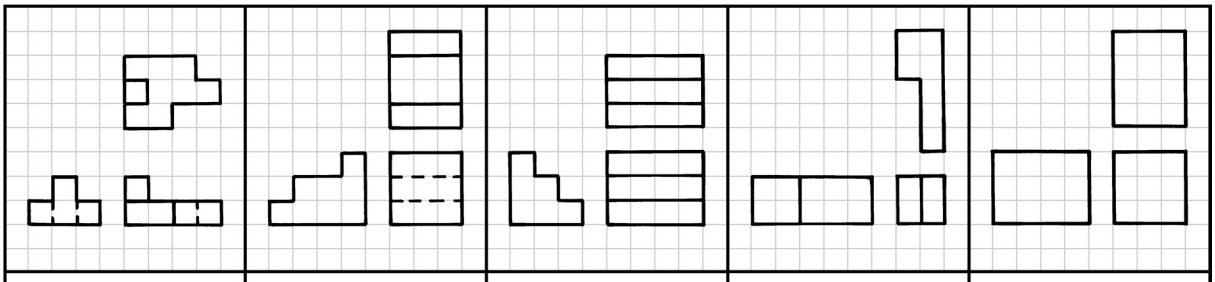


Problem 2.11	Problem 2.12	Problem 2.13	Problem 2.14	Problem 2.15

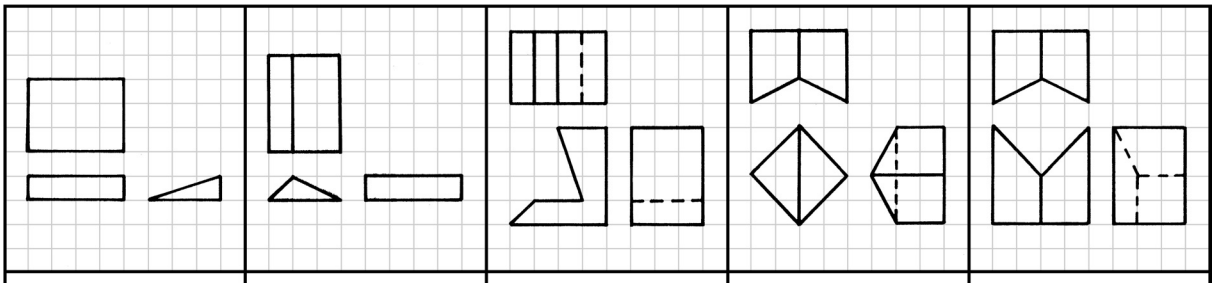


Problem 2.16	Problem 2.17	Problem 2.18	Problem 2.19	Problem 2.20

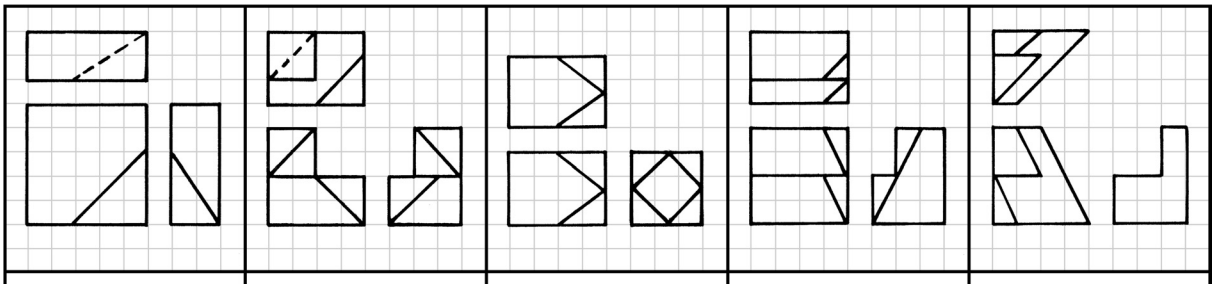
Problems 2.21–2.40
These problems are drawn in orthographic on a square grid. You are to sketch these objects in isometric on isometric grid paper. Note: Problems 2.21–2.25 have only normal surfaces, problems 2.26–2.30 also have inclined surfaces, problems 2.31–2.35 have oblique surfaces, and problems 2.36–2.40 have curved surfaces.



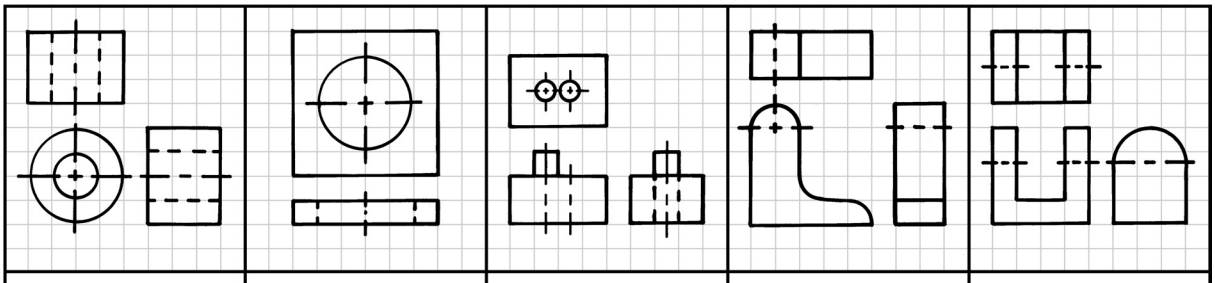
Problem 2.21	Problem 2.22	Problem 2.23	Problem 2.24	Problem 2.25



Problem 2.26	Problem 2.27	Problem 2.28	Problem 2.29	Problem 2.30

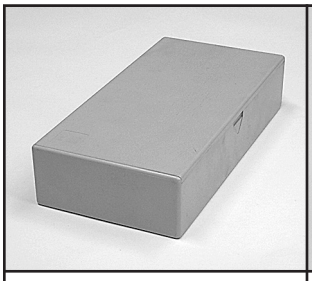


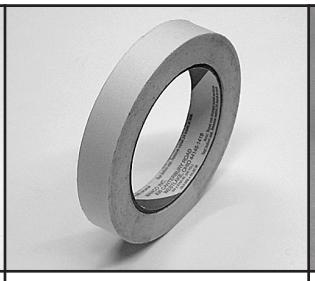
Problem 2.31	Problem 2.32	Problem 2.33	Problem 2.34	Problem 2.35

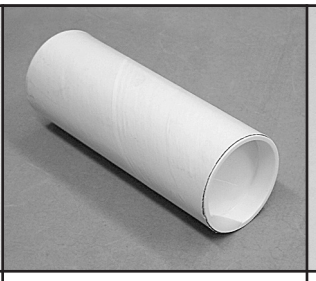


Problem 2.36	Problem 2.37	Problem 2.38	Problem 2.39	Problem 2.40

Problems 2.41–2.44
Sketch these photographed objects in isometric and add simple shading to the appropriate surfaces of each object.

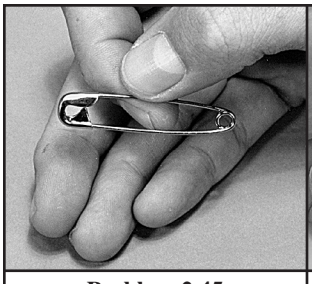

Problem 2.41

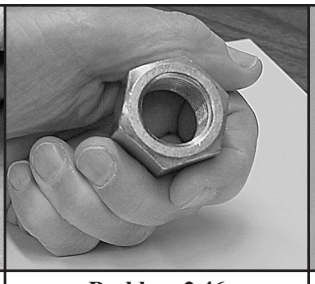

Problem 2.42

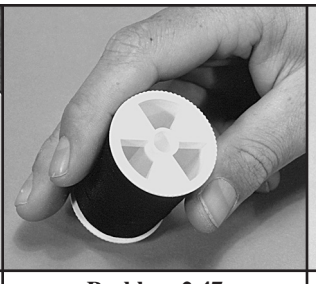

Problem 2.43

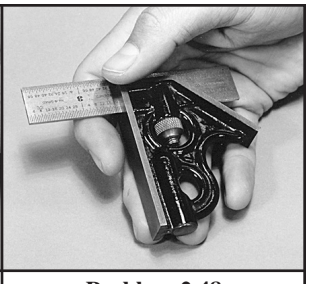

Problem 2.44

Problems 2.45–2.48
Sketch these photographed objects in isometric and add a sketch of your hand holding each of these objects.


Problem 2.45


Problem 2.46


Problem 2.47


Problem 2.48

Problems 2.49–2.52
Sketch these photographed objects in isometric.


Problem 2.49


Problem 2.50


Problem 2.51


Problem 2.52

Problem 2.53
Sketch in isometric a cube (length of sides X) that has a cylinder extending from the center of each of the six faces of the cube. The axis of each of the cylinders is $2X$, and the diameter is $\frac{1}{2}X$.