2.1 TECHNICAL SKETCHING

It is important to emphasize to the students the role that sketching plays in the engineering design process and how **technical sketching** differs from other types of sketching, such as those used in the fine arts. Many students have the mistaken impression that since sketching is less precise than manual drafting or CAD, it is less important. They don't realize that good sketching is an acquired skill and just because sketching is less precise doesn't mean that it should be sloppy or confusing. It may be worth noting that in many applications, technical sketches are required to follow the same graphics conventions that are imposed on formal drafted or CAD-produced drawings.

2.1.1 FREEHAND SKETCHING TOOLS

Note that though sketches can be created with any kind of drawing instrument on most any kind of paper, a good quality **pencil** and paper will help a beginning student. The instructor will have to decide their policy on the use of **grid paper**. Some feel it is a great way to support orthogonal and isometric line sketching in beginning (or advanced) students, but others feel it becomes a crutch which prevents them from becoming proficient on plain paper. The same decision goes for the use of **tracing paper**.

Another important issue is the use of straight edges. Students feel a tremendous need to produce that 'perfect' line. It is the opinion of this author that when you start using a straight edge, it is not longer a true sketch and you have lost much of the speed and flexibility advantage of sketching.

2.2 SKETCHING TECHNIQUE

Students will come to your class with a truly diverse abilities to mentally create and manipulate graphic imagery (**visualization**). Either through their life experiences or through innate ability, some students are simply better at visualization than others. This does not mean that those who don't come to your class with strong skills can't be taught many of the skills presented in the text. What it does mean is that it will be worth your while to try to informally assess your student's visualization abilities; either through exercises presented in this chapter, direct observation, or other methods. The ability level of your students may influence the level of instruction needed to get students to an appropriate level of proficiency.

It is important to emphasize the dynamic qualities of the visualization process. Not only can this dynamic process be taking place solely in one' head, but also between the mind, the eyes, and some physical stimulus such as a drawing or an object.

To apply these ideas in a more functional way, have your students experience this **feedback loop**. If you have already done some sketching exercises, then ask them to sketch a simple object in pictorial form. Now verbally describe changes you want them to make in their object (e.g. drill a hole through it, chamfer a corner, etc.). Ask them to first mentally imagine this operation and then sketch it. They can also do this completely on their own; have them start with a simple shape and then transform it into a common household object over a series of four or five sketches.

One of the most fundamental techniques in sketching is **contour sketching**. This technique defines the edges and contours of the object. The lines also define the boundary between the object and the surrounding space.

Variations on contour sketching include negative space sketching and upside-down sketching.

Encourage students to explore with different paper positions and body postures for drawing their lines. Emphasize the need to develop an appropriate balance of speed and accuracy in their linework. Encourage them not to look right at where the pencil is but to where the pencil is going to. **Intermediate points** (especially for curved lines) can be of great help in creating lines which follow the marked path.

Get students comfortable with sketching out squares to guide circle and circular arc construction and rhomboids for elliptical curves. With the **guide boxes** in place, have students develop a feel for the proper curvature relative to the box. Trying to sketch without guide boxes is a common pitfall with beginning students and happens almost as often on small diameter circles as it does with large ones.

2.3 PROPORTIONS AND CONSTRUCTION LINES

A logical extension of the use of guide boxes for circles and ellipses is the use of bounding (guide) boxes for developing the **proportions** of the sketch. Emphasize the importance of their use since all but the most gifted students are unlikely to have the visualization skills necessary to control the sketch proportions 'on the fly'. Encourage them to not only make small hash marks to mark distances, but to draw complete construction lines. These lines subdivide regions of the sketch and help the student refine the object from a rough whole to a detailed sketch. This process goes hand in hand with developing a student's visualization skills of looking at objects at various levels of detail; from the overall shape of an object to the details of particular features to where these features are located on the overall object.

2.4 LETTERING

1.76-7 Lettering is certainly one area where CAD has definitively increased the speed and accuracy of engineering and technical drawing. On the other hand, sketching done by hand cannot take advantage of the computer. For that reason, lettering has been placed in the chapter on sketching. In addition, this section also introduces many of the text variables you have at your disposal when using a CAD system. If you have not introduced CAD yet in your course, you may want to come back and review portions of this section when you do.

In addition to the ANSI standards, you may have other rules of thumb to convey to the students. Good and bad examples of lettering are always helpful in illustrating these principles.

Again, if the emphasis on your course is on CAD, you may want to only briefly touch on this section. By having all the students do a small amount of practice lettering in class, you can identify those needing help and have them do some remedial work out of class. If your primary interest in lettering is for use on sketches, you may not want to discuss lettering guides, since they slow down sketching much in the same way straight edges do.

Emphasize that guidelines (construction lines) are just as important in lettering as they are in sketching and drafting. You may decide, however, that those students who don't seem to be having too much trouble keeping their lettering aligned vertically, can skip putting in their vertical guidelines.

Cover not only the design style of each of the letters but also the numbers. There especially is a tendency to use non-standard designs for numbers among beginning students. Proper spacing is also something important to cover. Emphasize that the idea is to have uniform volume between the letters, not necessarily uniform distances between the nearest elements of the letters.

Though different companies and industries may use different computer lettering styles, Single Stroke Gothic is still the ANSI standard. (In AutoCAD, the closest equivalent is Roman Simplex). There can be a tendency among students to go a bit wild with their font choices (if given the opportunity) on a CAD system.

Within the same font, there are quite a few ways of varying the lettering, including plain, bold, slant, aspect, alignment (justification), etc. Point out times where it is appropriate to use these options. Explain to your students that the object is always drawn full scale in the CAD system, but that lettering may have to drawn at something other than the ANSI standard 3mm to account for print/plot scaling; that is, the 3mm standard is for the size on the printed/plotted page.

2.5 TEXT ON DRAWINGS

Examples from Chapter 10 on production drawings might to helpful in explaining the different areas where text is used on a drawing. Note that lettering within the drawing area should almost always conform to the ANSI standard 3mm, but that different sized and style text is often incorporated in other areas such as the titleblock.

If you can, point out examples of graphics which would clarified with the addition of a small amount of text and text notes which would be clarified by the addition of some graphic elements.

2.6 SKETCHING USING A PARAMETRIC MODELING CAD SOFTWARE PROGRAM

A fundamental technique within most parametric modeling programs is to sketch 2-D features then use a 3-D construction operation, such as extrude, revolve, or sweep, to create a 3-D model. Feature tools used to capture design intent include:

- Dimensions—the primary tool for capturing the intent of a design through the description of the size and location of entities.
- Constraints—used to define the relationship of sketched entities to other entities, such as defining two lines as being parallel to each other or two lines of equal length (Figure 2.44).
- References—when constructing a feature, a sketch entity can reference existing features of a part or assembly, such as datums, edges, or axes.
- Relations—relationships can be established between two dimensions, such as using algebraic or trigonometric equations to create mathematical relationships between entities.

When using 2-D CAD programs, it is common to enter precise values for geometric elements. Instead of creating geometry with precise dimensions, geometry is sketched much like you would if you were creating a pencil sketch. The following guidelines are important when making a sketch with a parametric modeling program:

- The shape of the sketch is important, not the size.
- The dimensions used to describe the features should match the design intent.
- Geometric constraints of the features should match the design intent.

2.7 SUMMARY

Sketching is an important tool for quickly and efficiently communicating design ideas. It is a particularly useful tool early in the design process when several ideas are being explored. One of the appealing characteristics of sketches is the minimal amount of equipment needed for their creation. A pencil, eraser, and paper are the only tools really necessary for creating a sketch. Increasingly, software being developed to run on low-cost computer systems has many of the same attributes as hand sketching. This new software has the potential of allowing a more direct translation of sketched designs into final, refined models that can be used in manufacturing and construction.

Whether a sketch is created by hand or on the computer, there is a basic set of techniques that should be used. Sketches are meant to be quickly created approximations of geometric forms. Therefore, exact measurements are usually not used in sketching. Instead, construction line techniques are used to preserve the proportions of different features of the object.

The process of transferring the features of a 3-D object onto a 2-D sheet of paper is called projection. One way of defining the projection relates to whether the lines projecting the features of the object are all parallel to each other. The types of projection include isometric pictorial, oblique pictorial, and multiview. These projections constitute the most popular methods used in engineering and technical graphics. Another type of projection, perspective, more closely matches how you perceive objects in the real world. This type of projection is less commonly used, in part because of the difficulty in laying out the sketch, and also because of the distortions it creates in the features of the object drawn.

The graphical methods used in creating a sketch communicate considerable information. At times, however, words are more effective for providing information on a drawing. The use of a standard method of lettering ensures that text in a drawing will be clear and legible. Computers are used extensively for generating text. This is due in part to the flexibility with which text can be generated and modified to meet specialized needs. Later chapters in this book will go into more detail as to the proper use and placement of text in engineering and technical graphics.

The mind uses many visualization tools, working in concert, to interpret the 3-D world. The mind engages in constant problem solving in the interpretation process. Part of this problem-solving process is automatic. However, you can develop numerous sketching and modeling techniques that will help. With a better understanding of how the mind interprets what it receives, you can use conscious mental power to assist in this process. You can also learn to bring physical processes into play. For example, you may be

able to pick up an object and rotate it to gain a better understanding of the object. More importantly, you may be able to create a sketch which will help you in the visual problem-solving process.