Chapter 2

Drafting Equipment and Supplies

Objectives

The student will be able to:

- understand the function of manual drafting instruments and supplies
- complete a pencil drawing using drafting instruments
- measure with a civil engineer's scale
- measure with a mechanical engineer's scale
- measure with a metric scale
- measure with an architect's scale

Introduction

Because of the many advantages of CAD systems **(Fig. 2-1)** over manual drafting systems, the number of computer-generated technical drawings in manufacturing and construction is growing at a rapid rate. However, a successful drafter, designer, engineer, or architect must also be able to create drawings using conventional drafting instruments and supplies the for following reasons:

Figure 2-1
Computer-aided drafting systems are gradually replacing manual drafting. *(Courtesy of Hewlett Packard)*

1. A CAD system may not always be available.
2. Not all companies can or will supply CAD systems to every drafter.
3. Field drawings and instructional sketches must be completed in environments hostile to computers.
4. Creative design in many areas is still done in pencil.
5. There may be times when the CAD system cannot create a specific type of detail. It would be expedient to make a print of your drawing and complete the detail with manual drafting instruments.

Whether a drawing is prepared as a pencil sketch, inked instrument drawing, or computer-generated hard copy **(Fig. 2-2)**, the final output must be orthographically correct, dimensionally accurate, symbologically true, and easily readable.

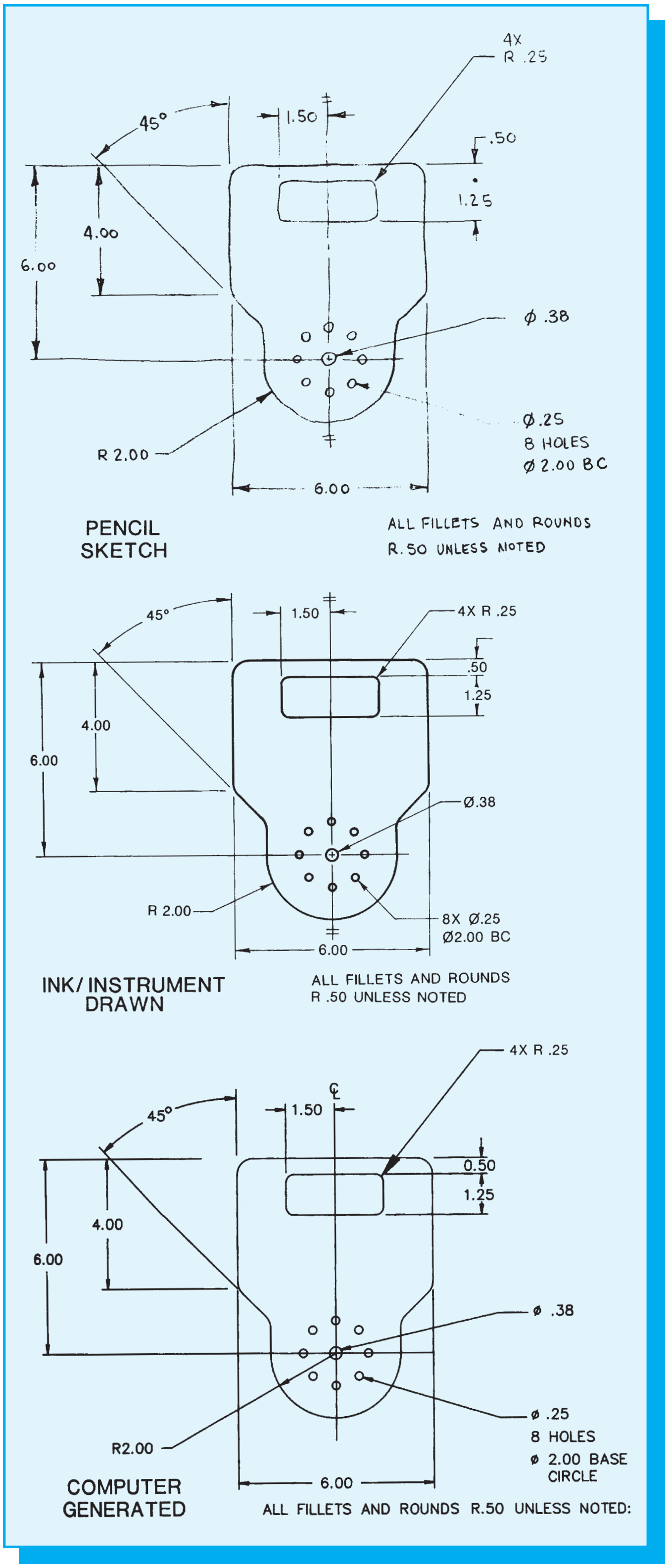

Figure 2-2
All finished working drawings must be easy to read.

Conventional Drafting Supplies

Conventional drafting supplies consist of surface media and marking devices. **Surface media** upon which pencil, ink, or CAD-plotted drawings are drawn include a variety of materi-als and surfaces such as **tracing paper, opaque drawing paper, vellum, film (Fig. 2-3)**, and preprinted **grid papers (Fig. 2-4)**. All drafting papers are held in place with drafting tape on the drawing board.

Marking devices used to make lines on surface media include pencils, pens, transfer film, and tapes. **Wood pencils** are the oldest type of drafting marking device **(Fig. 2-5)**.

Pencils and Lead Holders

Drafting pencils are classified by degree of lead hardness **(Fig. 2-6)**. Hard leads are used for fine layout work, medium leads for most object lines, and soft leads for lettering and rendering. To insure line weight consistency, pencils must be sharpened evenly **(Fig. 2-7)**. Sharp points produce fine lines, while round or dull points produce broad lines. Sharpening devices for drafting pencil points include hand or electric rotating sharpeners, cylindrical lead pointers, and sandpaper for hand-pointing leads.

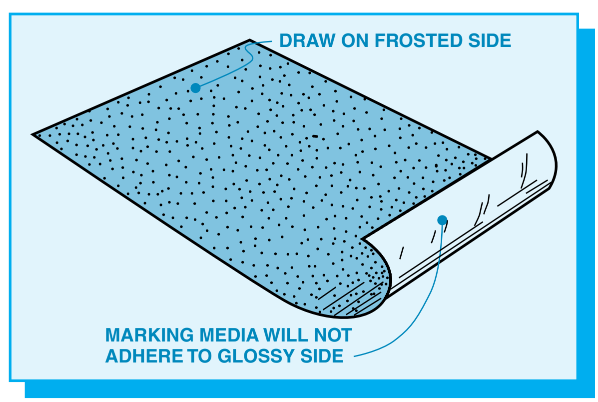

Figure 2-3
Drawing on polyester drafting film

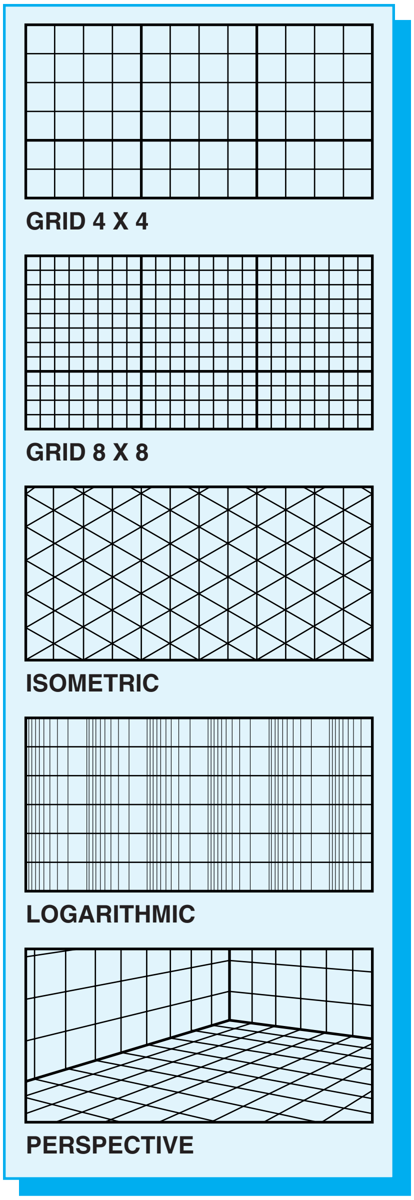

Figure 2-4
Examples of grid paper

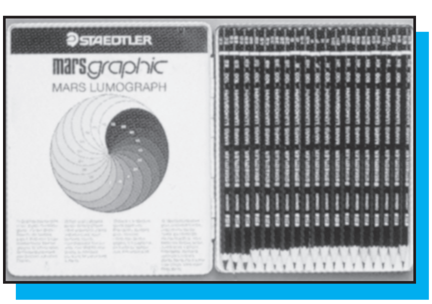

Figure 2-5
Typical wood-encased drafting pencil

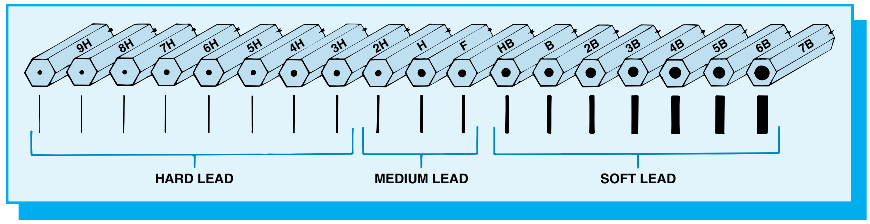

Figure 2-6
The various degrees of drafting pencils and their graphite lead widths

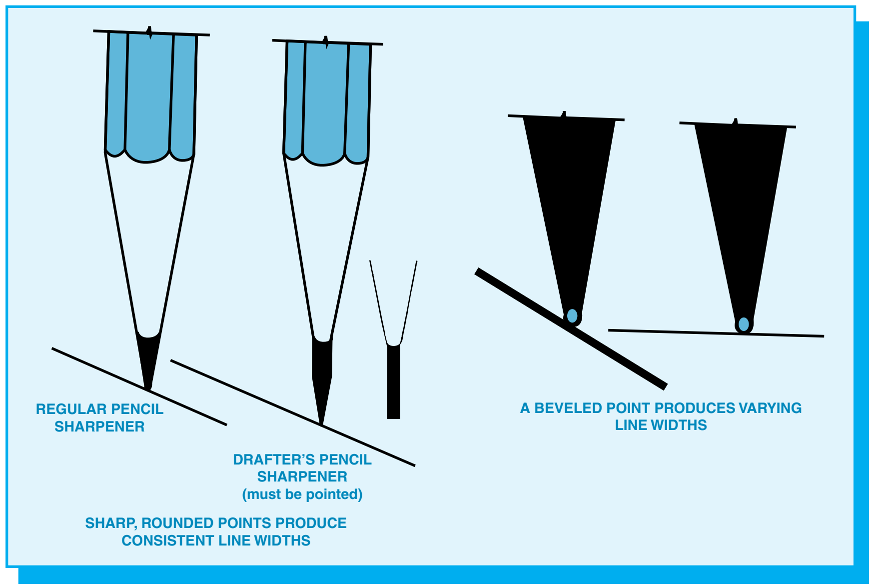

Figure 2-7
Pointing the drafting pencil

Figure 2-8
The lead holder grips the drafting lead. The lead can be sharpened on sandpaper, a file, or a mechanical sharpener. Leads are available in all drawing grades. *(Courtesy of Koh-I-Noor)*

Many conventional drafters prefer mechanical **lead holders (Fig. 2-8)**. These leads are not sharpened with a sharpener but pointed with a mechanical pointer or on a sandpaper block. Thin-lead mechanical pencils **(Fig. 2-9)** do not require either sharpening or pointing. Leads for mechanical holders are available in all grades; fine-line leads are available in thicknesses of 0.3, 0.5, 0.7, and 0.9 mm. Drafting leads are made of graphite, not lead. However, some drafting leads are made of plastic specially designed for use on drafting film.

After drawing with any graphite lead, remember to brush the surface periodically with a dusting brush to remove the accumulation of foreign matter and eraser leavings.

Figure 2-9
Fine-line mechanical pencils do not require sharpening. Leads are available in all drawing grades.
(Courtesy of Koh-I-Noor)

Technical Pens

A **technical pen (Fig. 2-10)** is an instrument used to ink lines and lettering on a technical drawing. Inking procedures are similar to pencil drawing except that care must be taken not to smear ink lines before they dry.

Technical pens are available in sizes from .13 to 2.0 mm. The line widths are coded in several ways, depending on the manufacturer. **Figure 2-11** shows typical line widths and two coding systems.

Figure 2-10
Technical inking pen
(Courtesy of Koh-I-Noor)

Erasers

Layout and construction lines often have to be removed, drafting mistakes corrected, and graphite smudges erased from drawing surfaces. An electric eraser **(Fig. 2-12)** is the most efficient line remover, since a gentle touch removes graphite or ink without damaging the surface. A medium-hard eraser with no abrasives is best for most drafting work. To erase ink from drafting film, a drop of water or commercial ink remover can be used. Very small ink areas can be removed by gently scraping with a sharp knife.

Softer graphite lines can be removed with a rubber or vinyl eraser, and smudges can be reduced by sprinkling the drawing surface with a powder cleaner. When using any eraser, always use an erasing shield **(Fig. 2-13)** to insure that only the desired line area is removed.

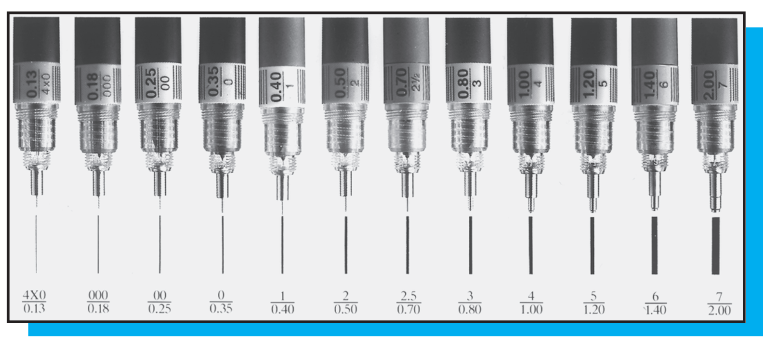

Figure 2-11
Technical pen identification designating line widths
(Courtesy of Faber-Castell)

Figure 2-12
The electric eraser is the most efficient cleaner.
(Courtesy of Koh-I-Noor)

Conventional Drafting Equipment

Regardless of the amount of work being done with CAD systems, or the number of CAD workstations, it would be convenient at times to have at least one manual drafting station for minor changes or detailing on CAD-generated drawings.

Drafting Machines

Track drafters (Fig. 2-14) are very efficient manual drafting machines. A track drafting machine includes a vertical track that slides left and right on a horizontal track. A protractor head is attached to the vertical track and allows the vertical scale (arm) and horizontal scale (arm) to be rotated to any angle. **Figure 2-15** shows the parts of a protractor head. Although the protractor head can be moved to any angle, an indexing button allows the arms to be automatically stopped every 15°. These are the angles commonly used in drawings.

Elbow drafting machines include a protractor head similar to the track drafter. The elbow machine **(Fig. 2-16)** is connected at the top of a drawing board. It cannot cover an area as large as that covered by a track drafting machine, but it is just as effective.

Large-scale drawings with continuous lines longer than the length of track or elbow machine arms are cumbersome to draw with an elbow or track drafter. For this reason, many large architectural drawings are made with a parallel slide drafting system. In a **parallel slide** system, the horizontal slide is used to draw all horizontal lines. Triangles are placed on the horizontal slide and used for all vertical and angular lines.

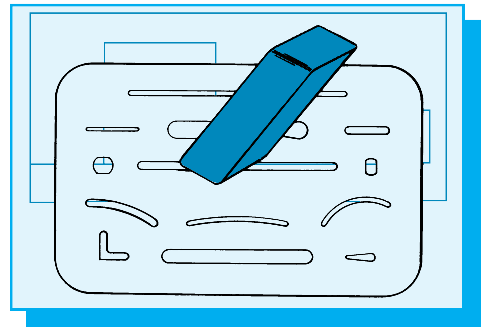

Figure 2-13
The erasing shield protects lines not to be erased.

Figure 2-14
The track drafter is a very efficient manual drafting machine.
(Courtesy of Vemco Corporation)

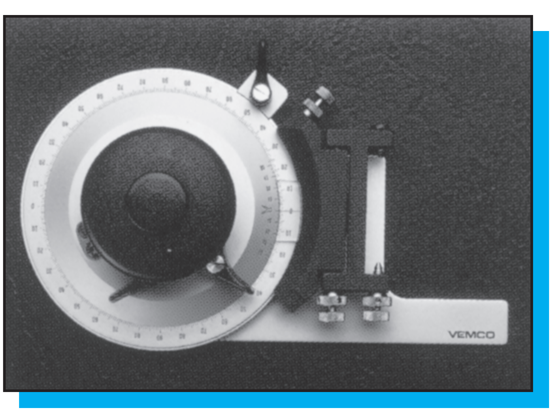

Figure 2-15
Parts of a protractor head for a drafting machine
(Courtesy of Vemco Corporation)

Figure 2-16
An elbow drafting machine and its parts
(Courtesy of Vemco Corporation)

T Square and Triangles

The use of the **T square (Fig. 2-17)** and **triangles** is one of the oldest drafting systems but tends to produce inaccurate lines if the T square is not rigidly held perpendicular to an edge at all times. **Figures 2-18** and **2-19** show the recommended method of mounting drawing paper onto a drawing board. When used with a T square or parallel slide, triangles **(Fig. 2-20)** are used to draw 15°, 30°, 45°, 60°, 75°, and 90° (vertical) lines. A 45° triangle is used to draw 90° (vertical) and 45° lines **(Fig. 2-21)**. A 30°– 60° triangle is used to draw 90°, 30°, and 60° lines **(Fig. 2-22)**. By combining triangle arrangements 15° and 75° lines can be drawn **(Fig. 2-23)**. For drawing angles other than at 15° increments, the protractor or the adjustable triangle can be used **(Fig. 2-24)**.

Figure 2-17
Example of a T square
(Courtesy of Teledyne Post)

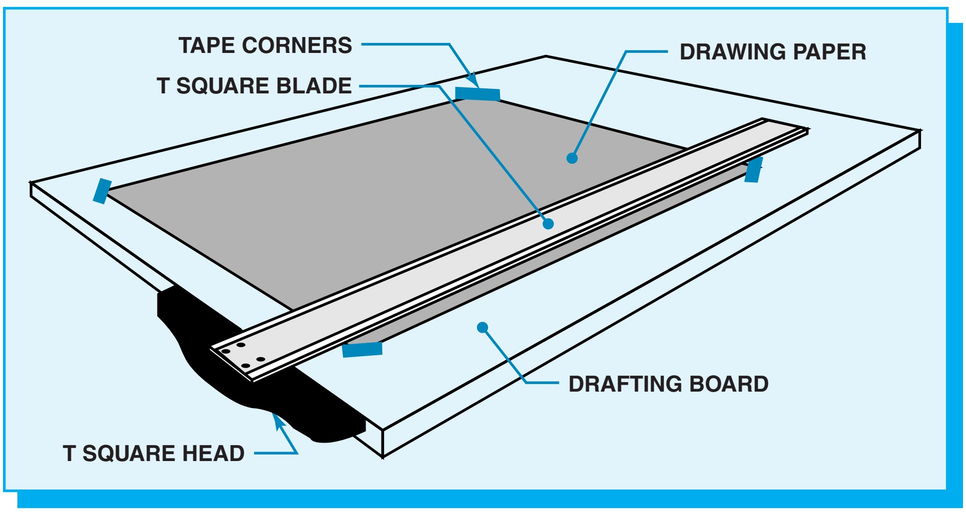

Figure 2-18
Line up drawing paper with T square on the drawing board as shown. Tape down corners of drawing media.

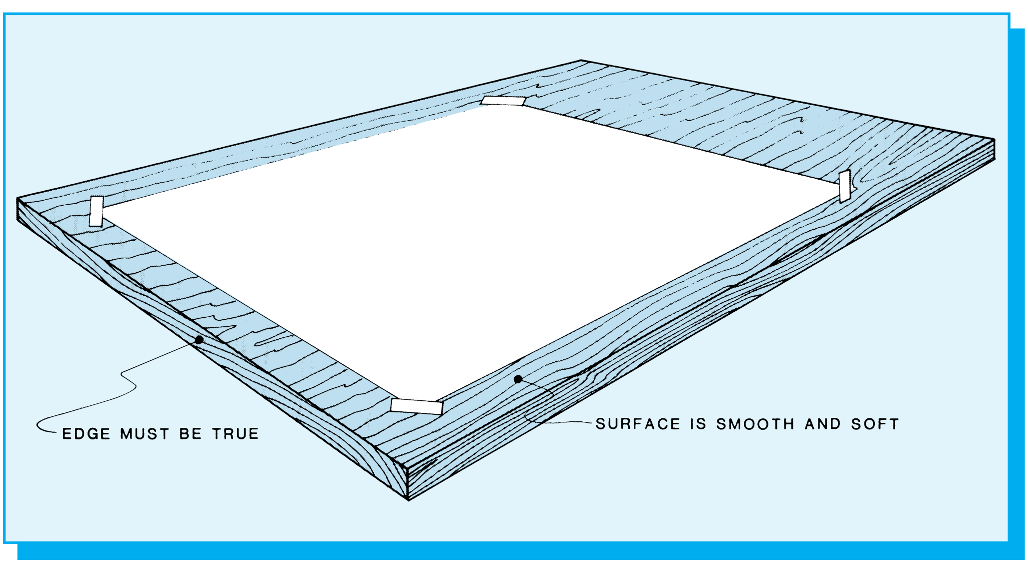

Figure 2-19
Drawing board qualities

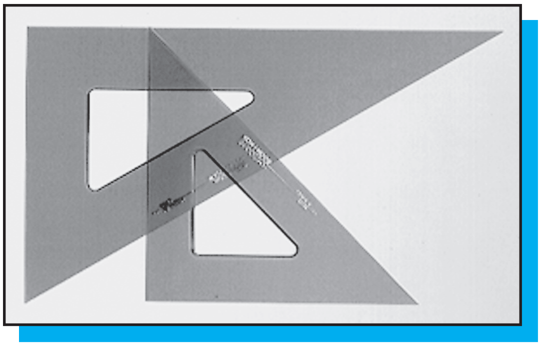

Figure 2-20
The 45° and 30°– 60° triangles
(Courtesy of Koh-I-Noor)

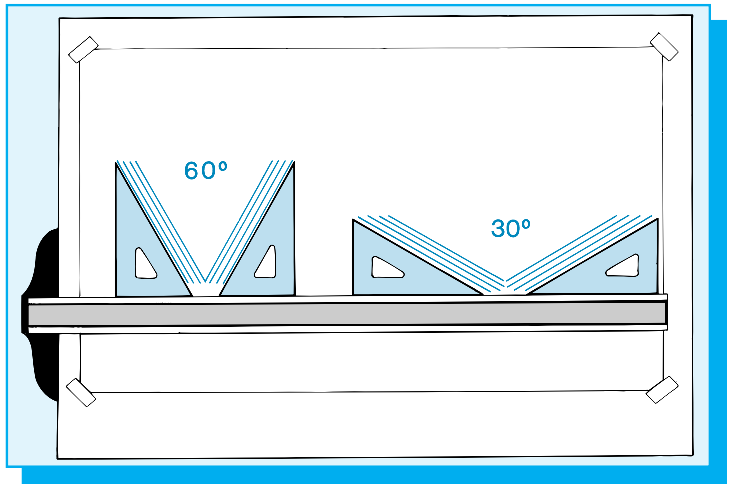

Figure 2-22
Positioning triangles to draw 30° and 60° lines

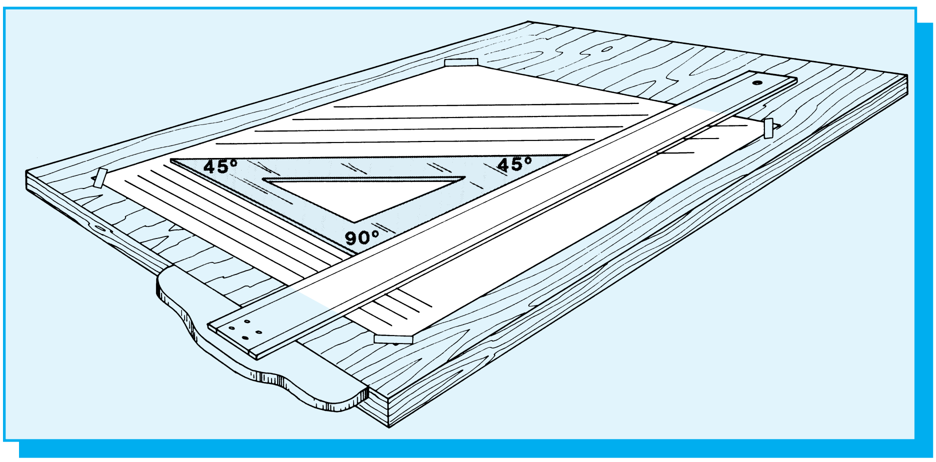

Figure 2-21
Drawing 45° and vertical lines

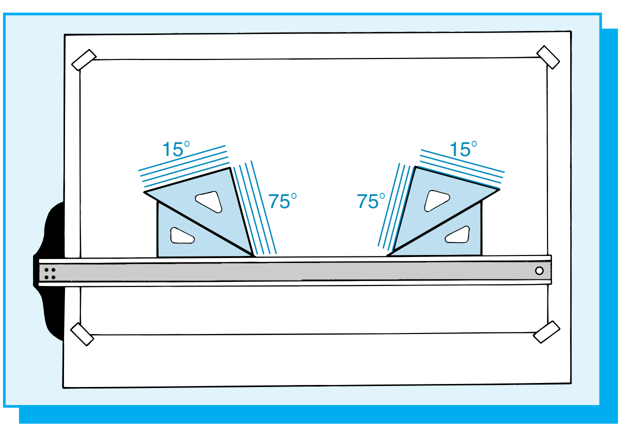

Figure 2-23
Positioning triangles to draw 15° and 75° lines

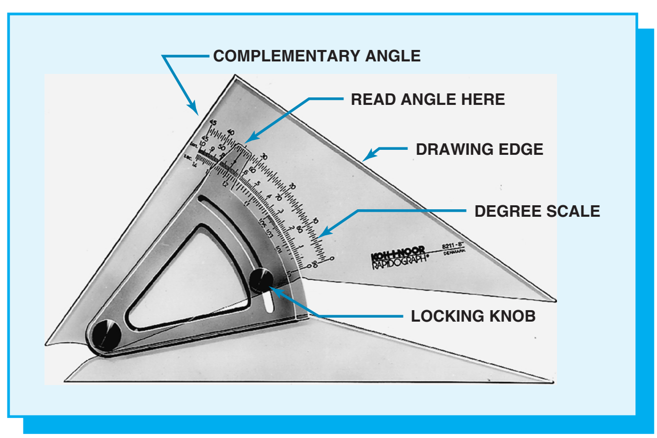

Figure 2-24
The adjustable triangle may be set to any angle.
(Courtesy of Koh-I-Noor)

Arc and Circle Instruments

All drawings are comprised of three kinds of lines: straight lines, arcs and circles, and irregular curved lines. Drafting machines can only be used to draw straight lines. Regular curved lines that radiate from a center point are drawn with a compass or circle template. There are three types of compasses used in drafting: bow, beam, and friction. **Bow compasses (Fig. 2-25)** are used for circles up to 12" in diameter, **friction compasses** are not recommended because they may slip while drawing circles, and **beam compasses** are used for large circles over 12" in diameter.

The bow compass is the most common of the three. It should be tilted and revolved between the thumb and index finger for best results **(Fig. 2-26)**. **Figure 2-27** shows the correct method of setting and sharpening a compass point and lead to produce the clearest and most consistent line quality.

Figure 2-25
Bow compasses and inking compasses are used for drawing circles and arcs.
(Courtesy of Vemco Corporation)

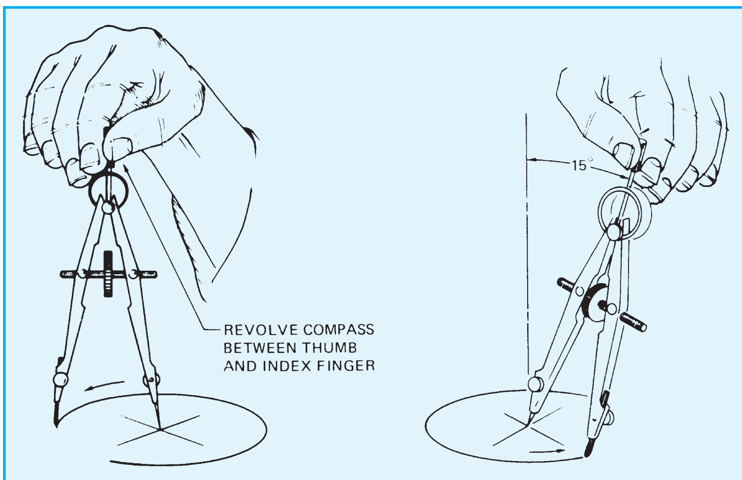

Figure 2-26
Drawing procedure for handling a bow compass
(Reprinted from Technical Drawing and Design *by Goetsch and Nelson, ©1986 Delmar Publishers Inc.)*

Dividers are similar to compasses except both tips are points. Dividers are used to step off or transfer distances on a drawing.

Irregular curves on technical drawings are drawn with the aid of an irregular curve template, sometimes called a French curve **(Fig. 2-28)**. When using a French curve, follow preplotted points in gradual overlapping progression **(Fig. 2-29)**.

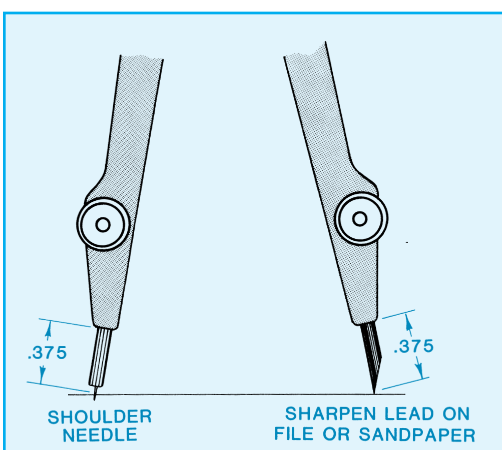

Figure 2-27
The compass point and the compass lead

Figure 2-28
A French curve is used to draw irregular curves.
(Courtesy of Teledyne Post)

Protractor

For manual drafting, a **protractor** is used to measure and lay out various angles **(Fig. 2-30)**.

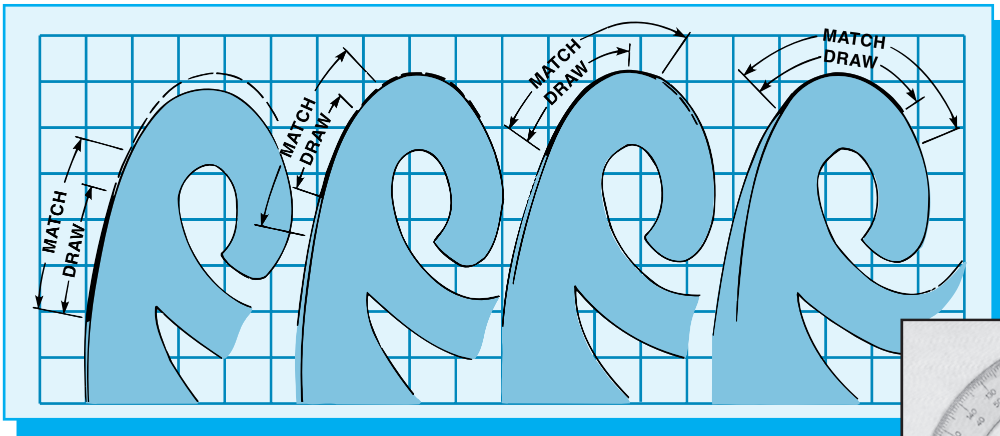

Figure 2-29
The procedural steps to draw an irregular curve with a French curve. *(Reprinted from* Mechanical Drafting *by Madsen, Shumaker, and Stewart, 1986 © Delmar Learning)*

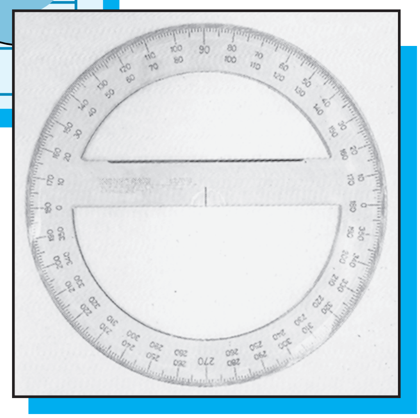

Figure 2-30
A semicircular protractor is used to measure angles in degrees. *(Courtesy of Koh-I-Noor)*

Mechanical Lettering Aids and Templates

For standard circles, ellipses, and arcs, one of the **templates** shown in **Figure 2-31** may be preferable to using a compass.

Templates also have the additional advantage of providing guides for drawing complete symbols, letters, and numerals. A template used for lettering guide lines is shown in **Figure 2-32**. Guide line templates are used by sliding the template along the top of a T square, slide, or blade with a sharp pencil inserted into a hole. The guides can be positioned to draw guide lines for different heights of lettering.

Figure 2-31
Sampling of some typical drawing templates

Drafting Scales

Whether you draw with manual equipment or with a CAD system, an understanding of different scales is essential. Scales are available in several different shapes **(Fig. 2-33)**. Scales allow drafters to create accurate drawings that are proportioned to the actual size of the object being drawn. Scales are based on either

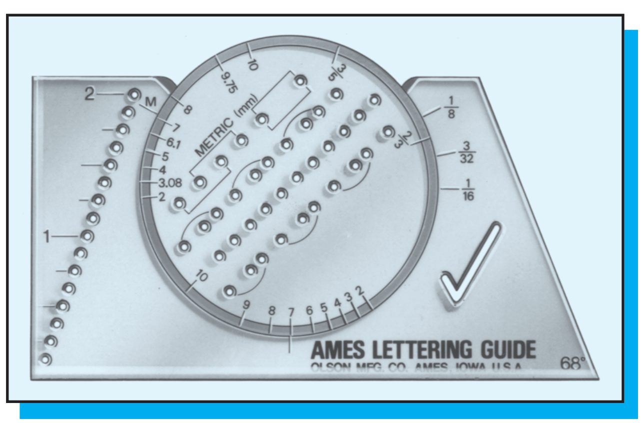

Figure 2-32
A guide line template is used by sliding the template along the top of the T square blade with a sharp pencil inserted into a hole. Various spaced guide lines may be drawn. *(Courtesy Olson Manufacturing & Distribution, Inc.)*

the **U.S. customary system** or the **metric system**. Scales used in drafting include the mechanical engineer's scale, the civil engineer's scale, the architect's scale, and the metric scale.

The **mechanical engineer's scale** uses a U.S. customary inch-fraction unit of measure **(Fig. 2-34)**. Scale subdivisions include $^1/_{32}$", $^1/_{16}$", $^1/_8$", $^1/_4$", $^3/_8$", $^3/_4$", $^1/_2$", and 1" units.

The **civil engineer's scale** uses a U.S. customary inch-decimal unit of measure **(Fig. 2-35)**. The inch-decimal unit is used by most industries using the U.S. customary system. Civil engineer's scale subdivisions include 10, 20, 30, 40, 50, and 60 parts per inch.

The **architect's scale** is used to prepare plans for structures. The foot is divided into twelve parts, so inches on a drawing can equal the actual inch or feet dimensions of a building **(Fig. 2-36)**. For example, most architectural drawings are prepared to a scale $^1/_4$" = 1'-0". This means that a $^1/_4$" line on a drawing represents one foot on a building. Thus, at $^1/_4$" = 1'-0" scale, an 8' wall would appear 2" long on the drawing. The various architect's scales are $^3/_{32}$", $^3/_{16}$", $^1/_8$", $^1/_4$", $^3/_8$", $^3/_4$", $^1/_2$", 1", $1^1/_2$", and 3".

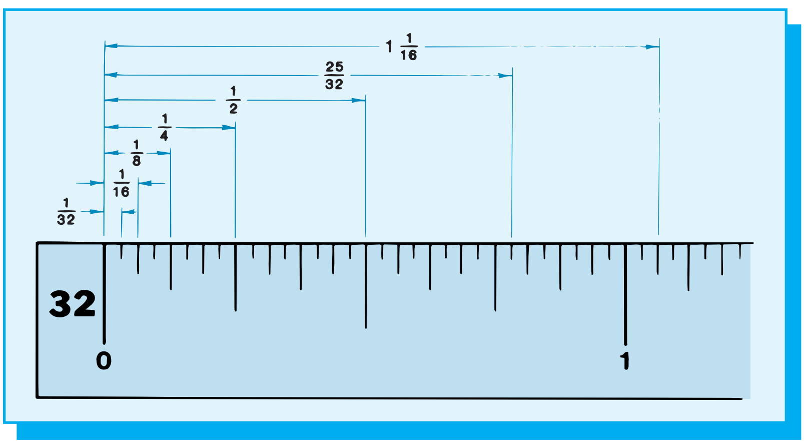

Figure 2-34
The mechanical engineer's scale uses inch-fraction units of measure.

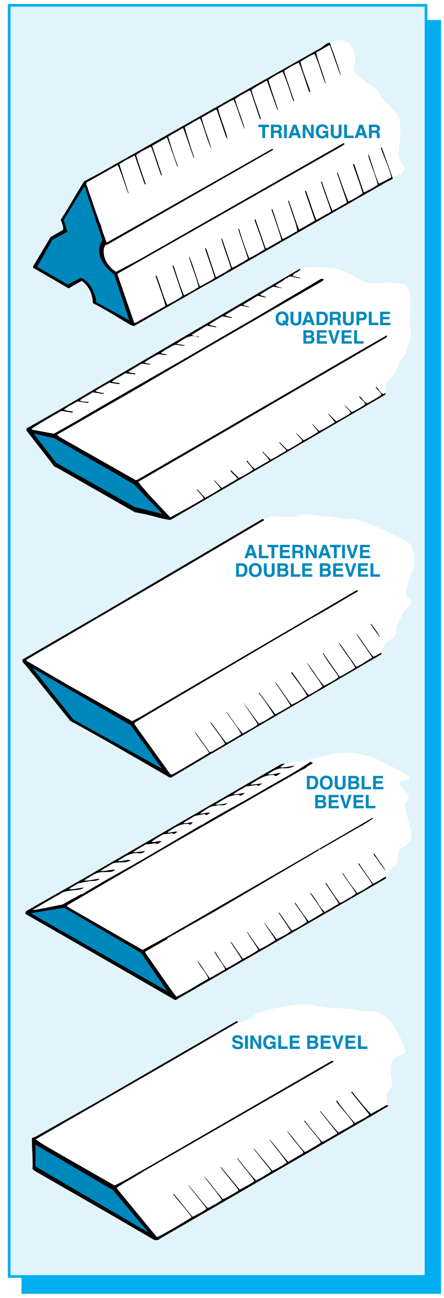

Figure 2-33
Various scale shapes

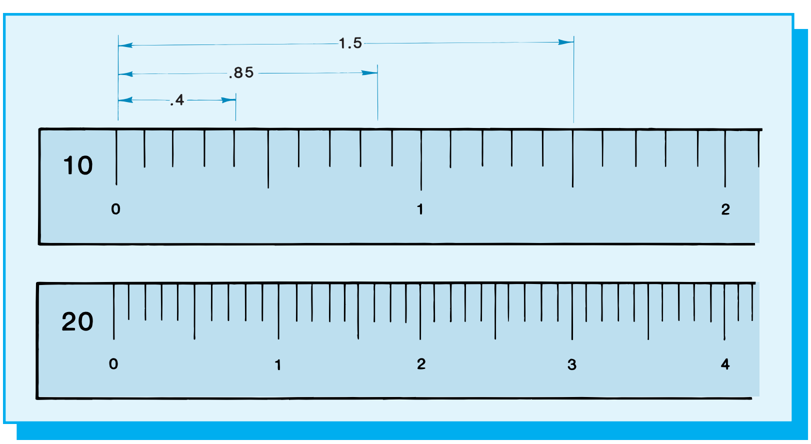

Figure 2-35
The civil engineer's scale uses inch-decimal units of measure.

The basic unit of measure for metric scales is the **millimeter (mm) (Fig. 2-37)**. The abbreviation mm is not used in metric drawings since all dimensions are in millimeters. All countries except the United States use the metric system for technical drawing and manufacturing, although we are gradually converting.

Drafting scales are either **open-divided** or **full-divided (Fig. 2-38)**. Only one major unit of open-divided scales is graduated with a full-divided unit. It is adjacent to the zero. Full-divided scales contain full subdivision lines throughout the entire length of the scale. In selecting the proper scale for each drawing, the drafter must consider the amount of space available, the readability of the finished drawing, and ease of drawing. **Figure 2-39** provides some basic guidelines for proper scale selection. In selecting a scale, remember that a decimal or fractional part of an inch can be made equal to any unit of measure such as an inch, foot, yard, or mile.

Manual Drafting versus CAD

As computer-aided drafting becomes more prevalent in schools and industry, a decision must be made as to how many CAD stations and how many manual drafting stations should be installed. The decision will depend on the needs, goals, and budgets of each school, industry, and business.

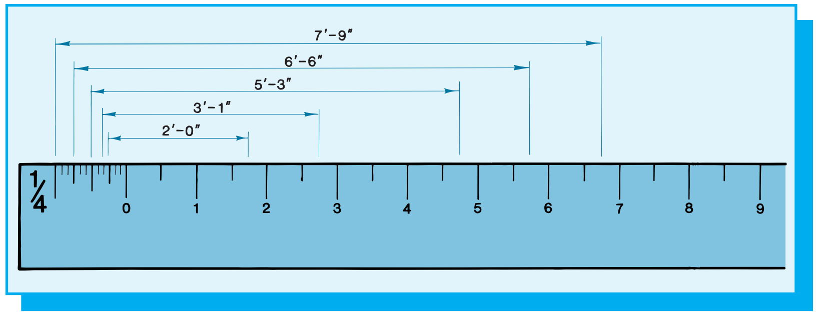

Figure 2-36
The architect's scale uses foot-inch units of measure. The most often used architect's scale is 1/4" = 1'-0".

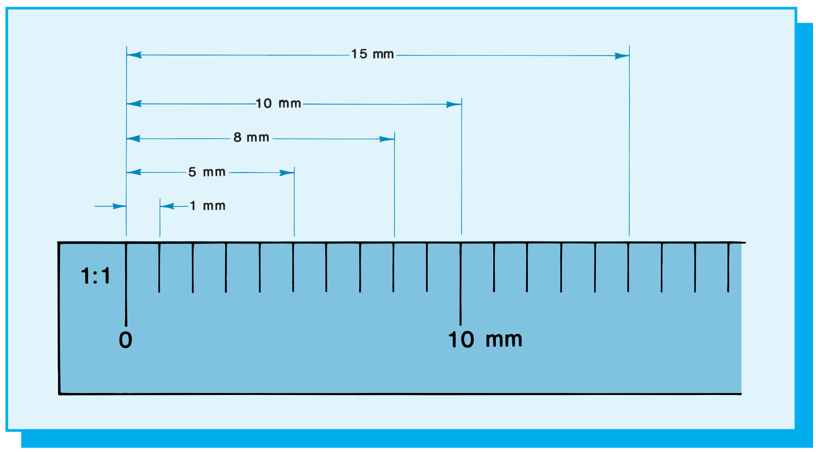

Figure 2-37
The basic unit of measure for metric scales is the millimeter (mm).

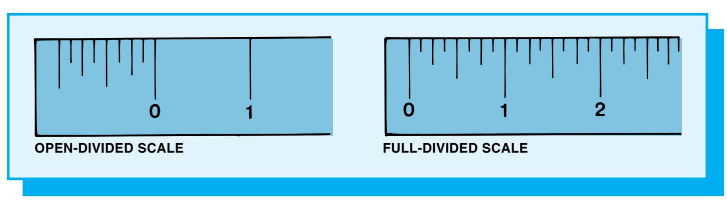

Figure 2-38
Drafting scales are either open-divided or full-divided.

SCALE SELECTIONS FOR ENGINEERING DRAWING			
Types of Drawings	Mechanical Engineer's Scale	Civil Engineer's Scale	Metric Scale
The object to be drawn must be smaller than the drawing format. All the drawings, dimensions, and notations will fit at actual size.	Full Size (1:1)	1:1	1:1
The object to be drawn is larger than the drawing format and must be reduced by half to fit the format.	1/2" = 1"	1:2	1:2
The object to be drawn is much larger than the drawing format and must be reduced eight to ten times in size to fit the drawing format.	1/8" = 1"	1" = 10" 1:10	1:10
The object to be drawn is very large, such as a building, and must be reduced at least fifty times in size to fit the drawing format.	1/4" = 1'–0" (1:48)	1:50	1:50
The object to be drawn is small and cannot easily be drawn full size. Doubling the drawing size makes the drawing easier to draw and interpret.	1" = 1/2" (2:1)	2:1	2:1
The object to be drawn is very small. For ease of drawing and interpreting, the original size must be increased eight or ten times.	1" = 1/8" (8:1)	10:1	10:1
When an industrial product is extremely small, such as circuitry chips, the drawings must be drawn approximately 100 to 500 times larger.	Not used	100:1 500:1	100:1 500:1

Figure 2-39
Typical scale selection for engineering drawings

1. Divide a "B" (11" × 17" or 12" × 18") drawing format into 11 parts as shown in **Figure 2-40**. Practice sketching the line work with drafting pencils.
2. Divide a "B" drawing format into 11 parts as shown in **Figure 2-40**. Practice drawing with instruments and drafting pencils.

   Measure each line in **Figure 2-41** with these scales:

   full size—inch-decimal

   full size—inch-fraction

   1/2" = 1"

   1" =10'

   full size—metric (millimeters)

   1/4" = 1′–0"
3. Practice drawing the line work in **Figure 2-42** with drafting instruments, freehand, and with a CAD system.

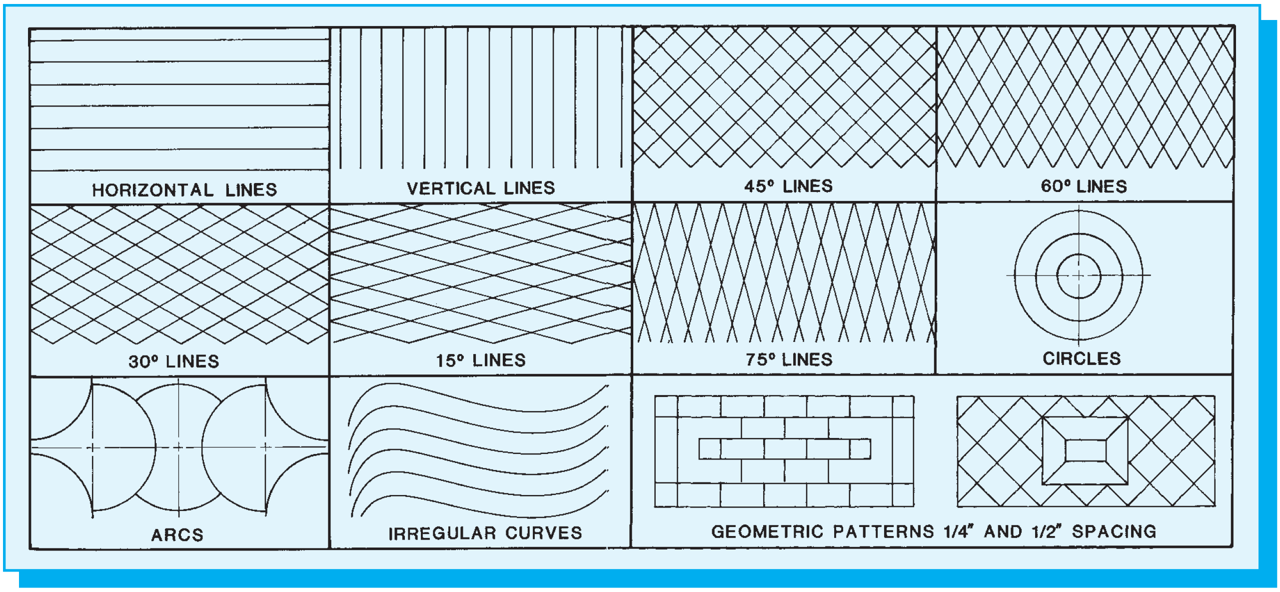

Figure 2-40
Divide four B-size drawing formats into eleven parts as shown. Practice the line work with pencil sketching, drawing instruments and pencil, drawing instruments and a CAD drawing.

Figure 2-41
Measure each line with as many different scales as are available.

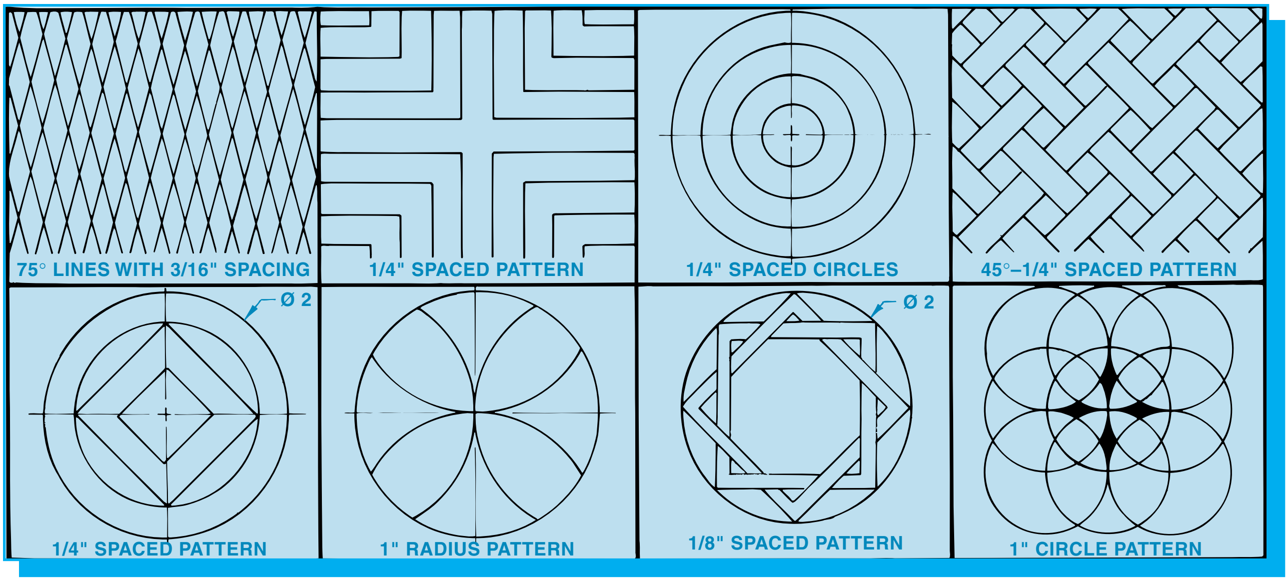

Figure 2-42
Practice drawing the line work.

1. With your drafting instruments, make a geometric design of your initials about 3" in height.

2. Design a dart board target with the scoring values.

3. Design a rifle range target.

4. With your drafting instruments, design and cut out a puzzle on stiff paper.

Architect's scale
Beam compass
Bow compass
Civil engineer's scale
Dividers
Drafting pencils
Elbow drafter
Film
Friction compass
Full-divided scale
Grid paper
Irregular curve
Lead holder
Marking devices
Mechanical engineer's scale
Metric system
Millimeter (mm)
Opaque drawing paper
Open-divided scale
Parallel slide
Protractor
Surface media
Technical pen
Template
Tracing paper
Track drafter
Triangles
T square
U.S. customary system
Vellum
Wood pencils