

CHAPTER

# 3

## TRADITIONAL DRAFTING TOOLS AND TECHNIQUES

### *Chapter* **Objectives**

- Describe the tools and techniques used in traditional drafting.
- Use technical pencils, straightedges, triangles, scales, protractors, and templates to construct the geometry of technical drawings.
- Read a conversion table to convert between decimal, fractional, and metric units.
- Use traditional drafting tools to create multiview drawings of objects including the correct placement and depiction of visible, hidden, and center lines.
- Hand-letter notes and dimensions on technical drawings that are clear and legible.

Refer to the following websites:

- Koh-I-Noor: <http://www.kohinoorusa.com/>
- Alvin: [www.alvinco.com](http://www.alvinco.com)
- Pentel: [www.pentel.com](http://www.pentel.com)
- Staedtler: [www.staedtler.com](http://www.staedtler.com)

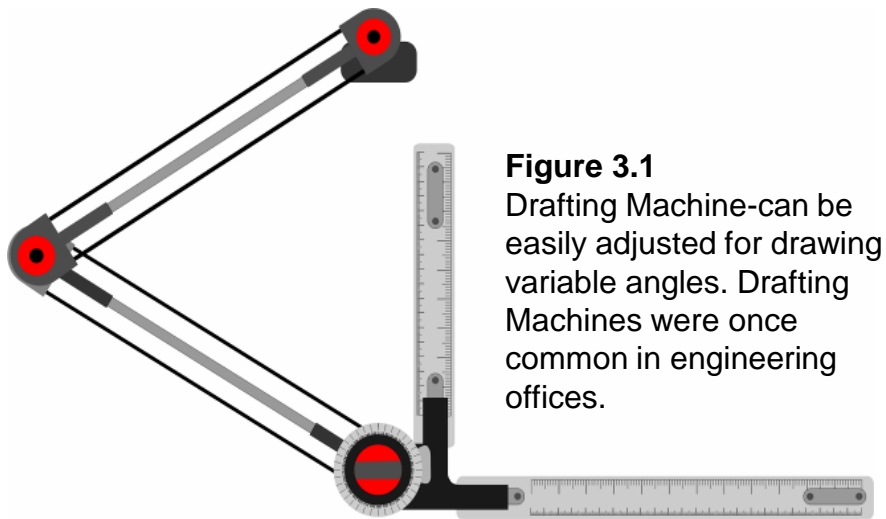


# Traditional Drafting Tools and Techniques

Before Computer-Aided-Design revolutionized the way technical drawings are produced, drafters and designers sat at drawing tables and used traditional drafting tools like technical pens, triangles, scales, protractors, templates and straight-edges to draw on sheets of vellum or mylar (a thin sheet of plastic with a matte surface).

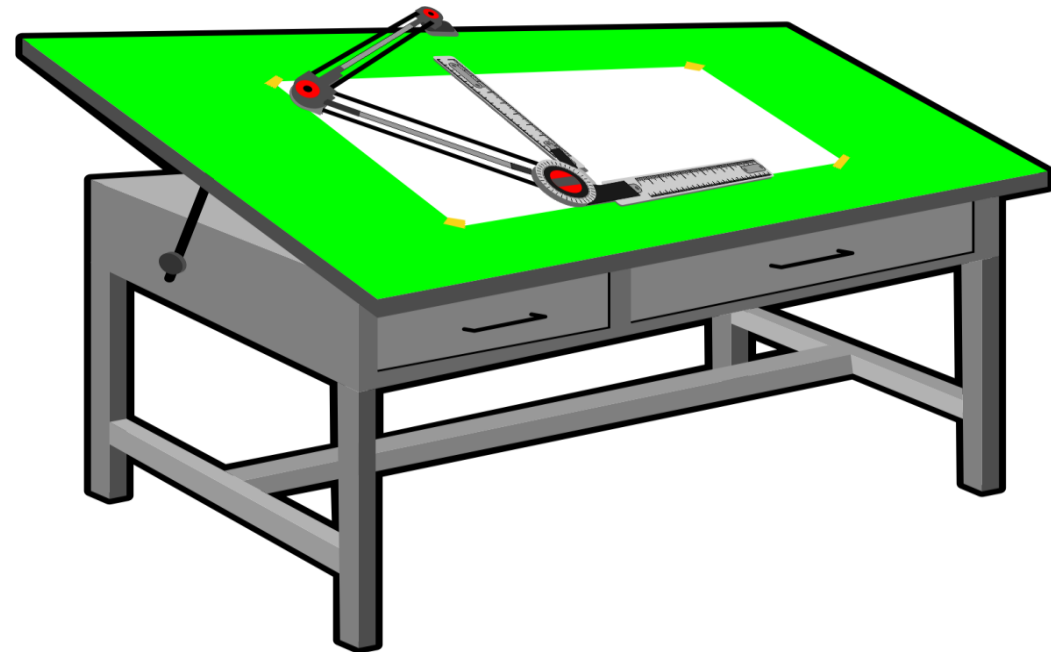
In today's engineering or architectural office, it would be rare for a drafter to create a drawing in the traditional way, but many of the techniques developed by traditional drafters, like orthographic projection, are still used to create 2D CAD drawings. The traditional tools discussed in this unit can be purchased through drafting supply outlets.

Shown in **Figures 3.1** through **3.3** are examples of traditional drafting equipment. A **Drafting machine**, or a **parallel straight-edge**, attached to the top of a **drawing table** allows a drafter to draw horizontal lines that are parallel to each other. Another tool that can be used to draw parallel horizontal lines is a **T-Square**.



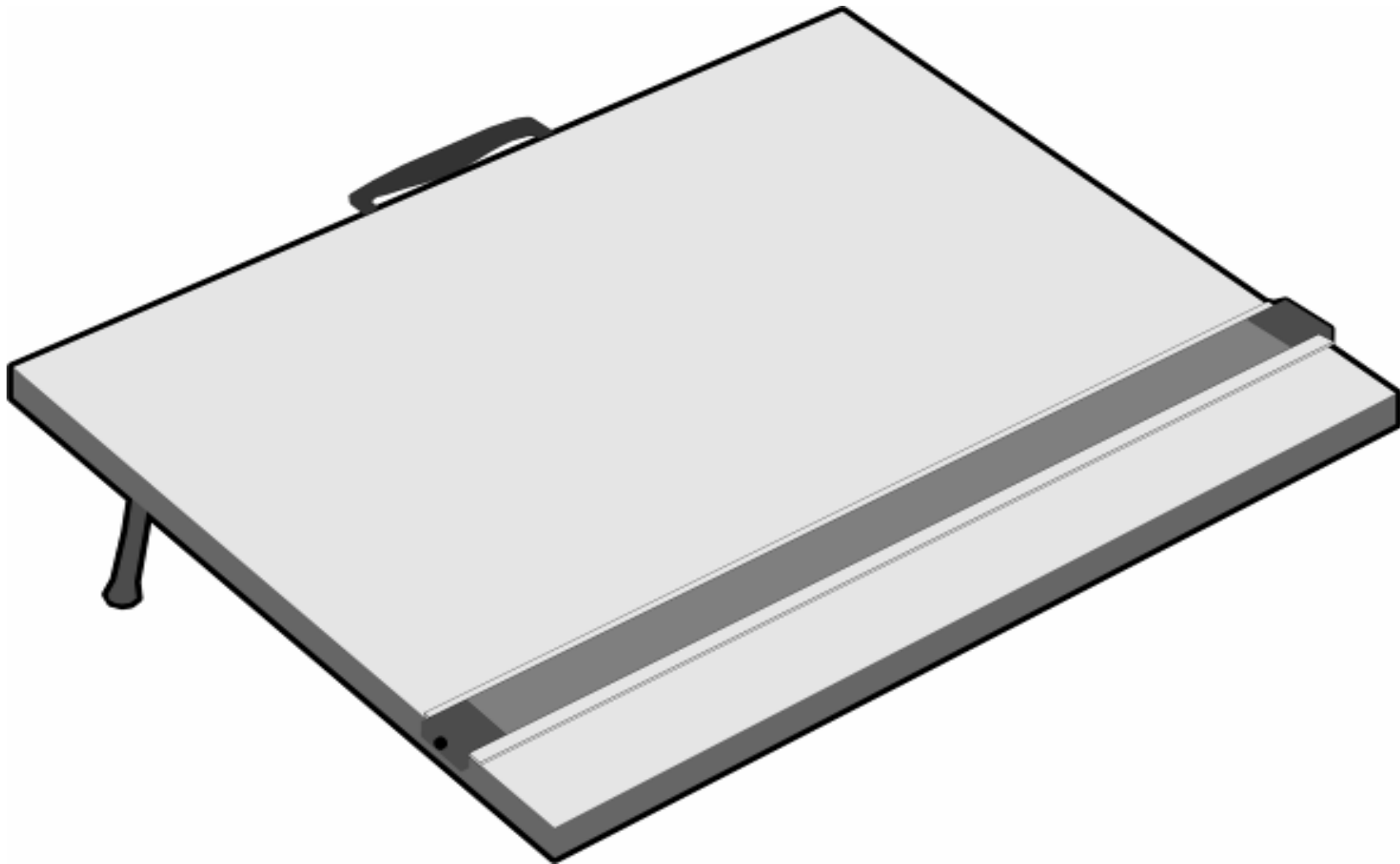
**Figure 3.1**  
Drafting Machine-can be easily adjusted for drawing variable angles. Drafting Machines were once common in engineering offices.

**Figure 3.2** Drawing Table with Drafting Machine



## Traditional Drafting Tools and Techniques

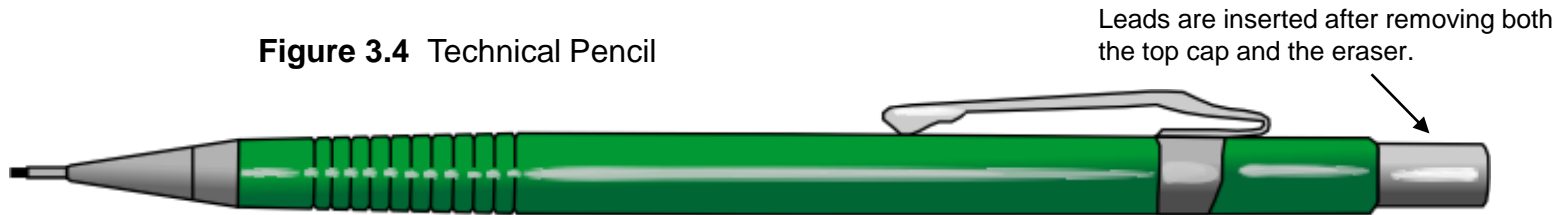
**Figure 3.3** Parallel Straight-edge Attached to the Top of a Portable Drawing Table



## Technical Pencils and Pens

Professional grade technical pens and pencils are often used by design professionals to create technical drawings (See **Figure 3.4**).

**Figure 3.4** Technical Pencil



Technical pens and pencils come in differing line widths (.3mm, .5mm, .7mm, .9mm) and leads for technical pencils are available in a variety of hardness grades depending on the type of work to be performed.

**Table 3.1** shows the lead hardness grades and the appropriate application for the leads in each hardness range.

**Table 3.1** Pencil Lead Hardness Grades and Applications

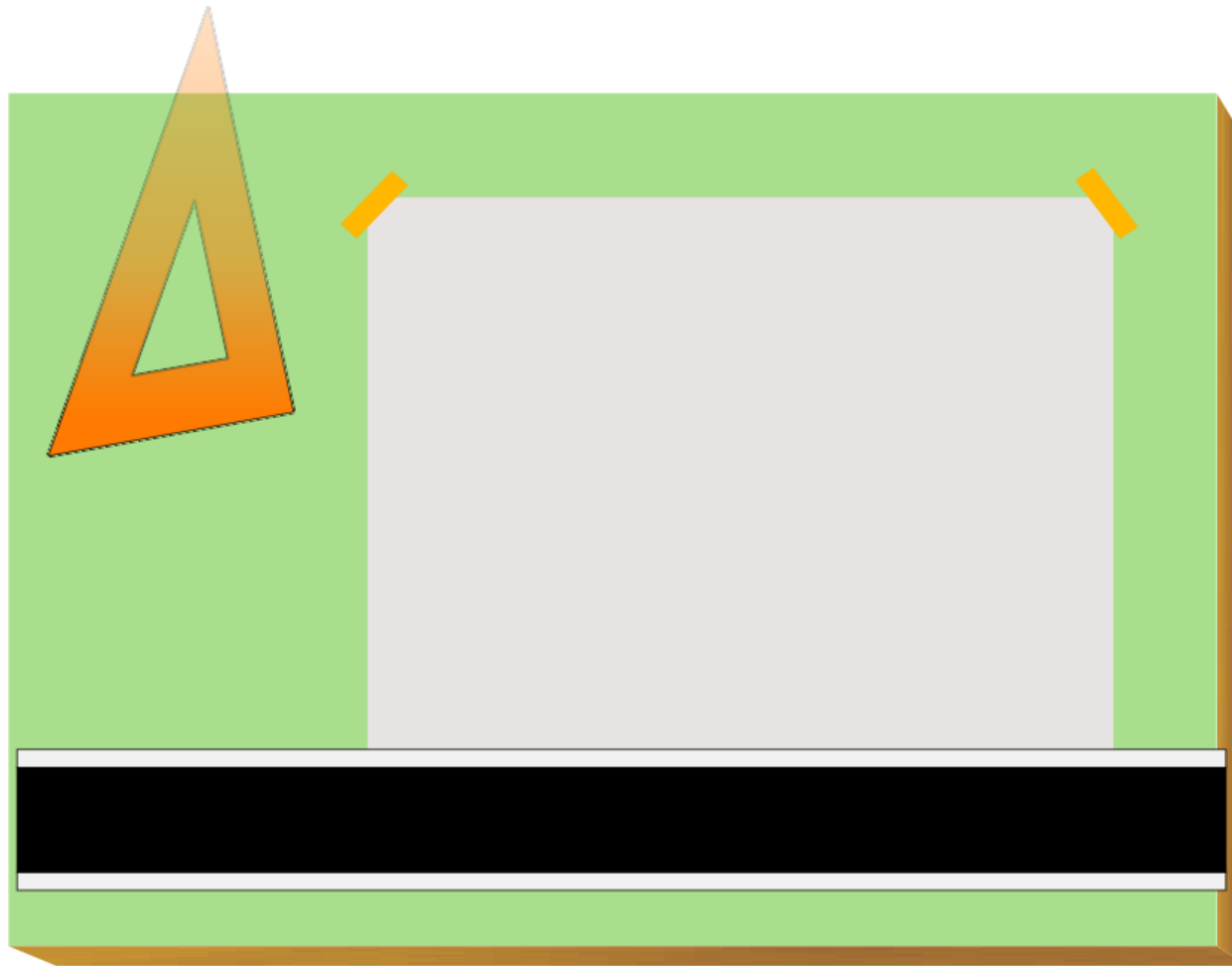
Technical Drawings										Graphic Arts									
9H	8H	7H	6H	5H	4H	3H	2H	H	F	HB	B	2B	3B	4B	5B	6B	7B	8B	9B
Hard: Construction lines, Layout.																			
Medium: Lettering, Hidden, Center, Dimension.																			
Medium: Lettering, Section and some Visible lines.																			
Medium Soft: Visible and Cutting Plane lines.																			
Soft: Visible and Cutting Plane lines. Lead loaded in Mechanical Pencils.																			
Soft: Sketching, Drawing, Art Layout.										Very Soft: Shade, Shadow, Textures. Artists.									
Technical Drawing, Design, Layout.										Sketching, Design, Layout, Art									



## Beginning a Traditional Drafting Project

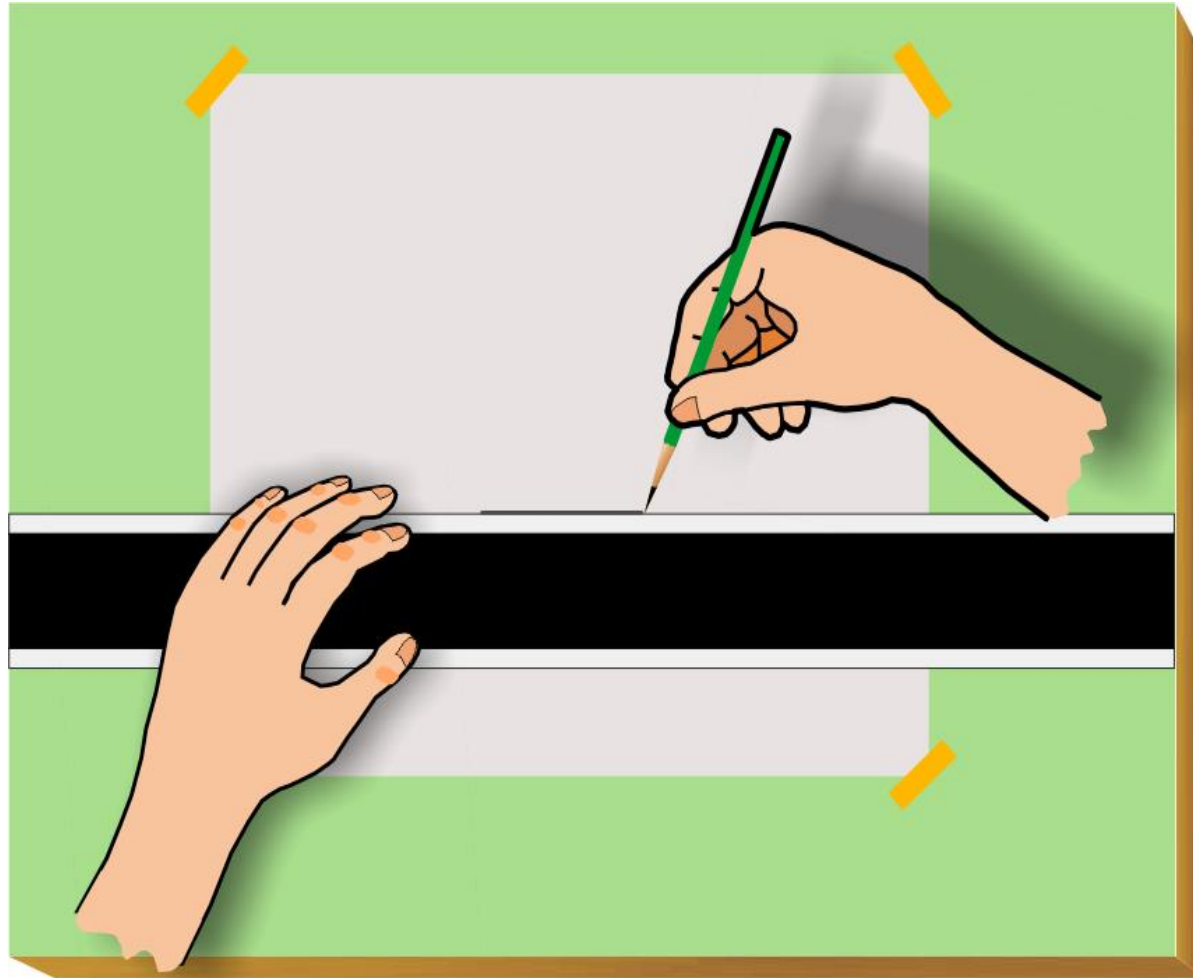
**Figure 3.5** illustrates the proper technique for attaching a sheet of vellum to the top of a drawing table. Align the bottom edge of the sheet to the top edge of the drafting machine arm, parallel straightedge, or T-Square and tape all four corners to the table top. Horizontal lines can be drawn on the sheet by drawing along the top edge of the straight-edge.

**Figure 3.5** Aligning the Bottom Edge of a Sheet of Vellum to the Top Edge of a Parallel Straight-edge



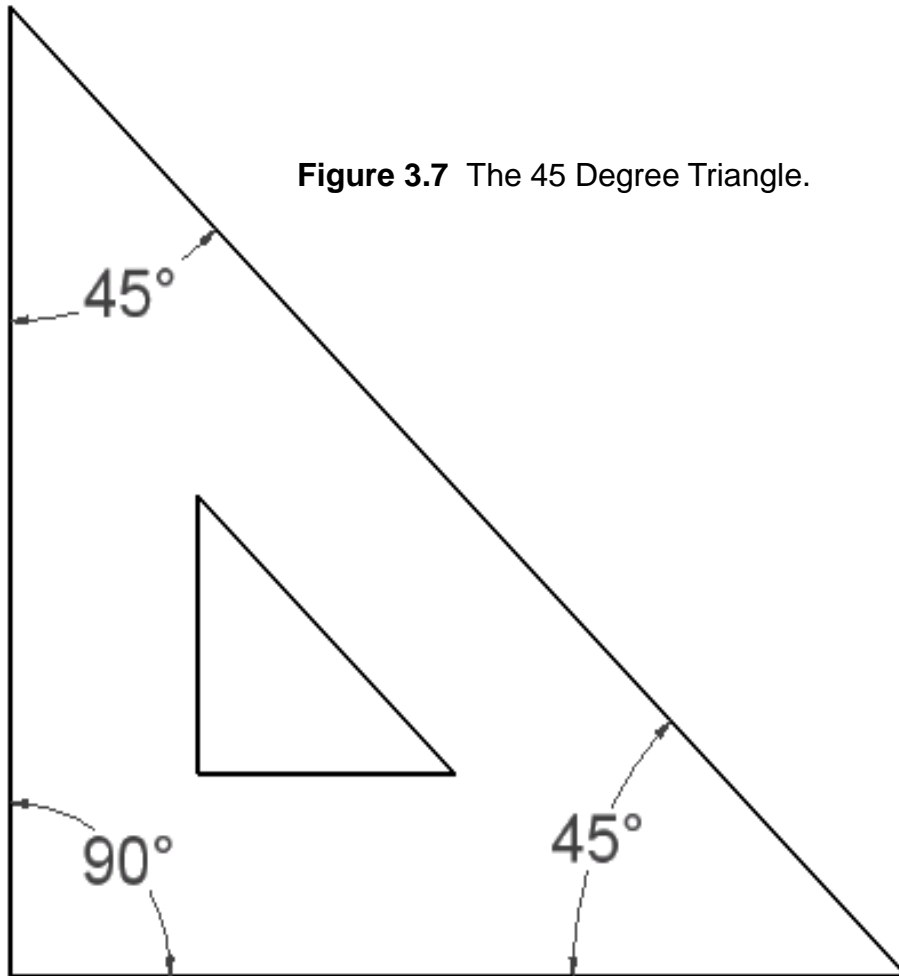
Horizontal lines are drawn along the top edge of the straight-edge as shown in **Figure 3.6**. A right-handed drafter holds the straight-edge in place with her left hand when drawing a horizontal line.

**Figure 3.6**



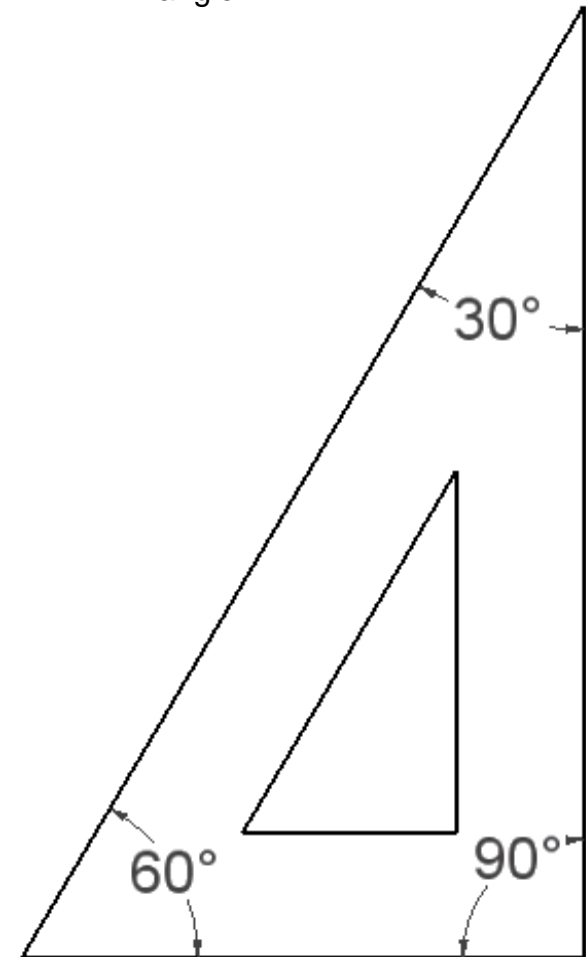
## Drafting Triangles

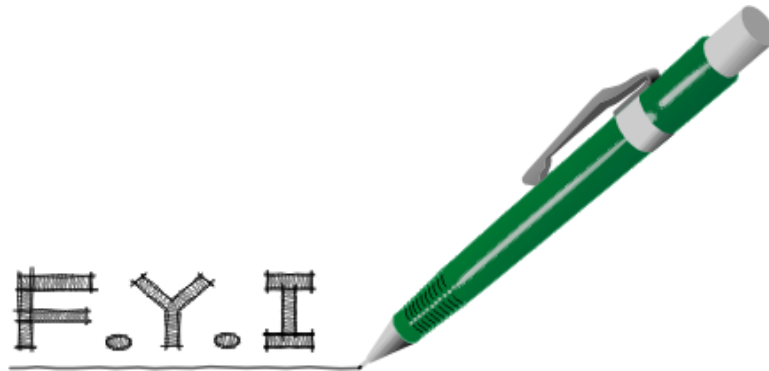
Triangles, like the ones shown in **Figures 3.7** and **3.8**, provide drafters with angles commonly used in technical drawings-30, 45, 60, and 90 degrees. Triangles are usually made of acrylic plastic and are available in a variety of sizes.



**Figure 3.7** The 45 Degree Triangle.

**Figure 3.8** The 30/60 Degree Triangle.





There are triangles designed for drawing with lead and others for drawing in pen and ink. Inking triangles have a beveled, or stepped, edge to prevent the ink from running under the edge of the triangle and smearing.





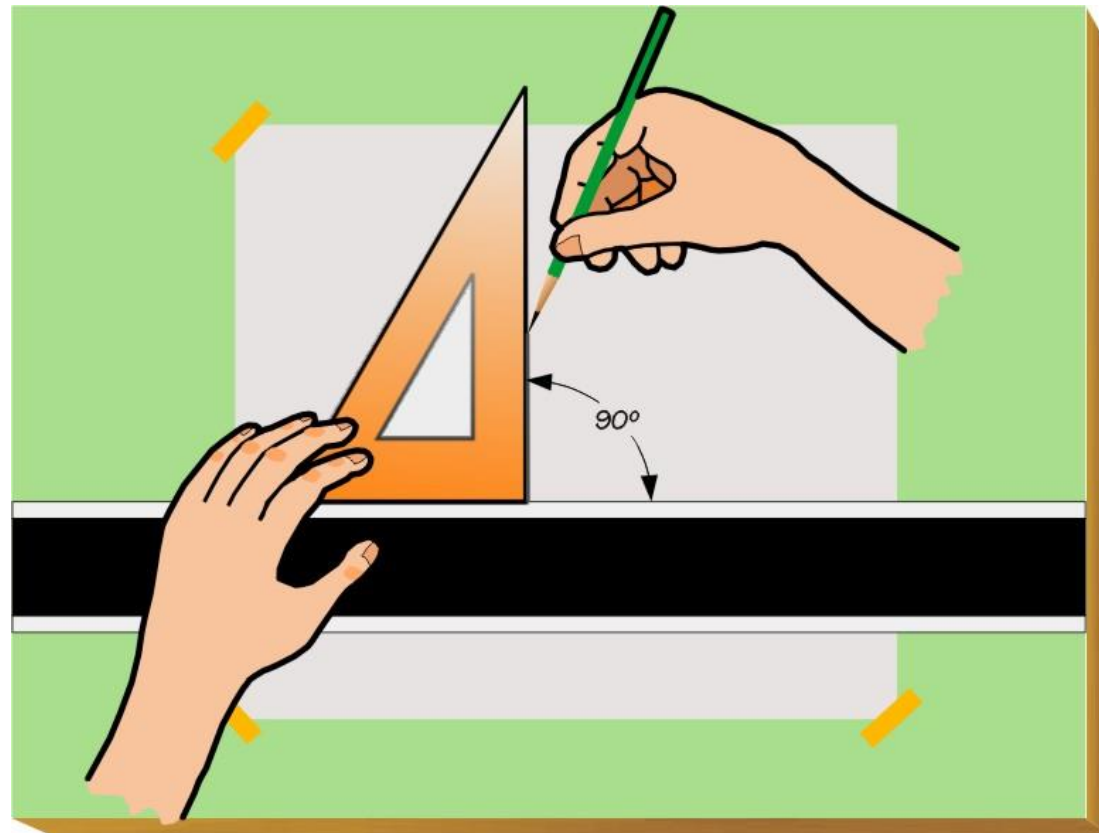
## Drawing Lines with Triangles and Parallel Straight-edges

To draw horizontal and vertical lines that are mutually perpendicular (90 degrees), drafters use a triangle in conjunction with a parallel straight-edge.

To draw vertical lines, the triangle should be placed on top of the straight-edge as in **Figure 3.9**. In this way you are assured that a vertical line will be at a 90 degree angle relative to a line drawn along the top of the parallel straight-edge.

Hold both the straight-edge and triangle with your left hand while drawing the vertical line. You can use either the 30-60 triangle (as shown), or the 45 degree triangle.

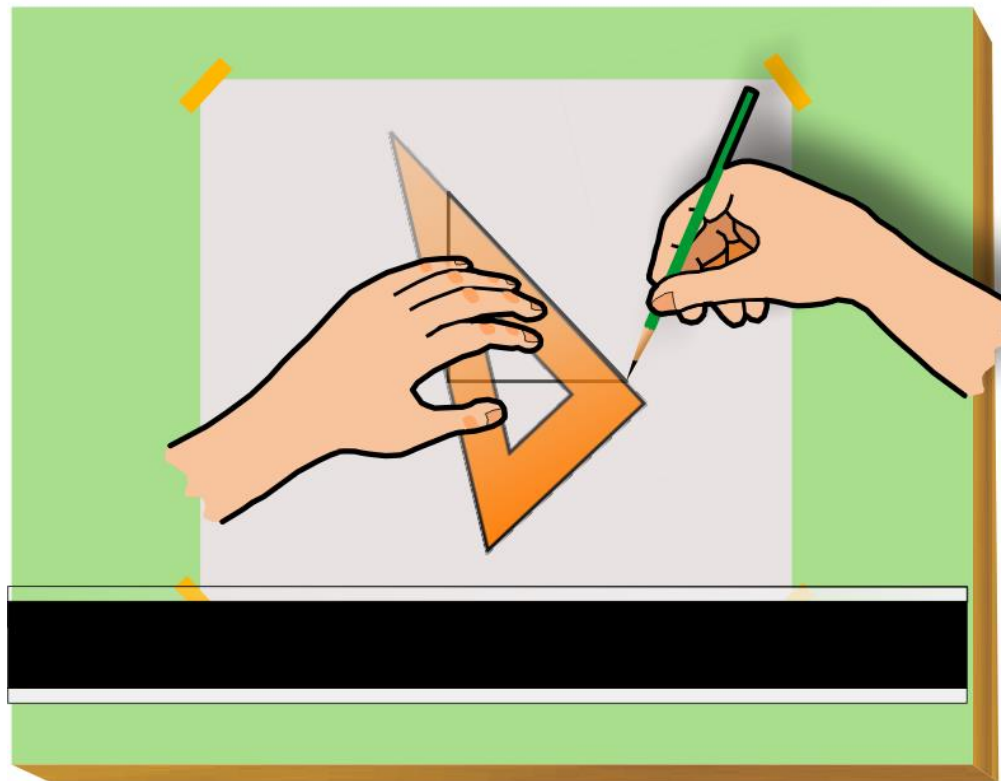
**Figure 3.9** Drawing a Vertical Line



Often beginning students erroneously believe that holding a triangle as vertical as their eyes can position it (known as “eye-balling”) and drawing a line will give them a perpendicular vertical line, when in fact, the only way to draw an accurate vertical line is to make sure the triangle rests on the straight-edge as shown in **Figure 3.9**. However, there are occasions when **floating** the triangle is necessary, for example, when connecting two points, or the ends of two lines, when the angle of the resulting line is not equal to 30, 45, 60, or 90 degrees.

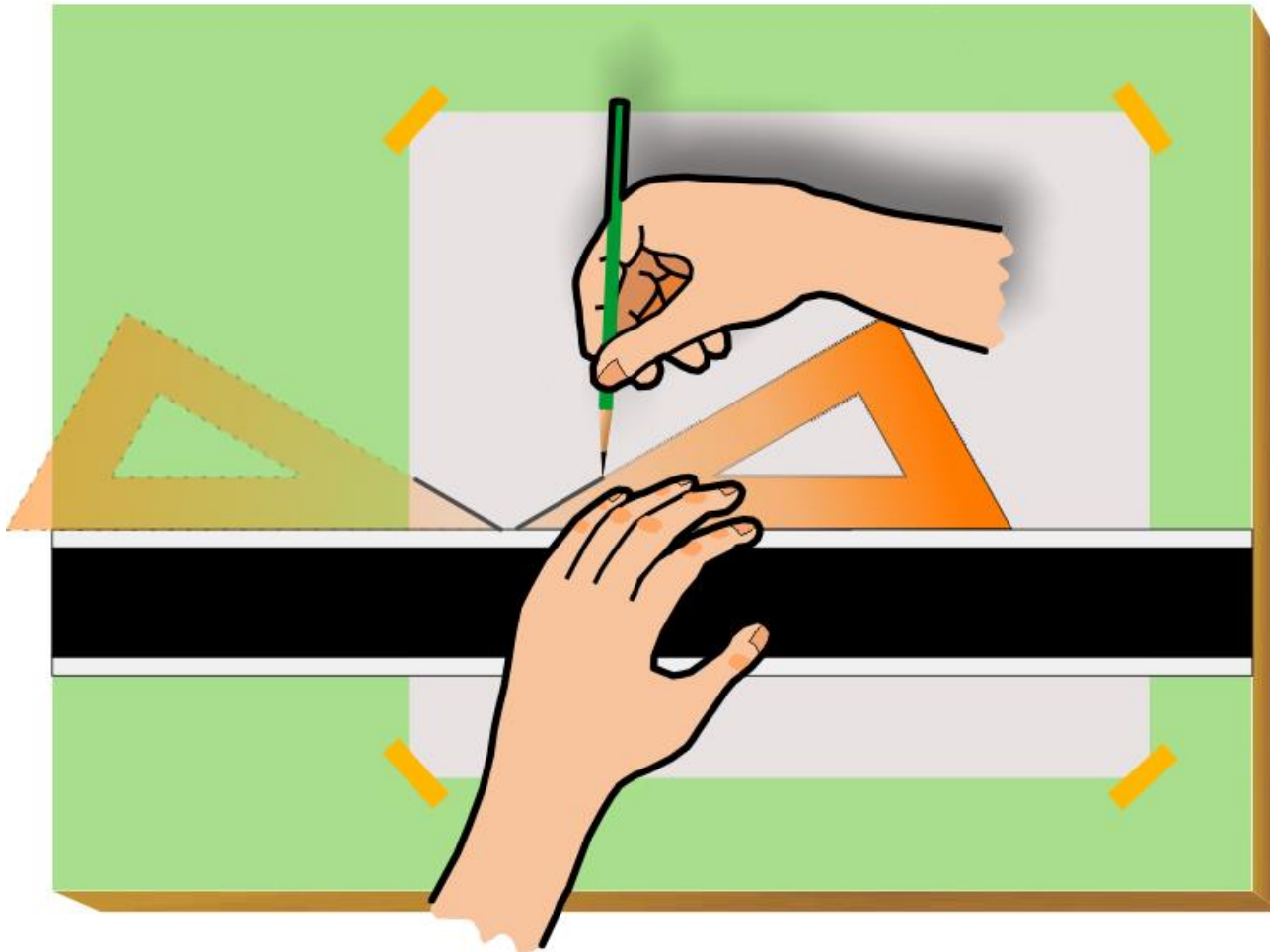
In **Figure 3.10**, vertical and horizontal lines have been drawn and the drafter would like to draw a line connecting their end points. The desired angle does not match one of the triangle’s normal angles (30, 45, 60, or 90 degrees). In this case, the triangle would be floated and aligned with the ends of the vertical and horizontal lines. The line is drawn between the points along the edge of the triangle.

**Figure 3.10** Floating the Triangle



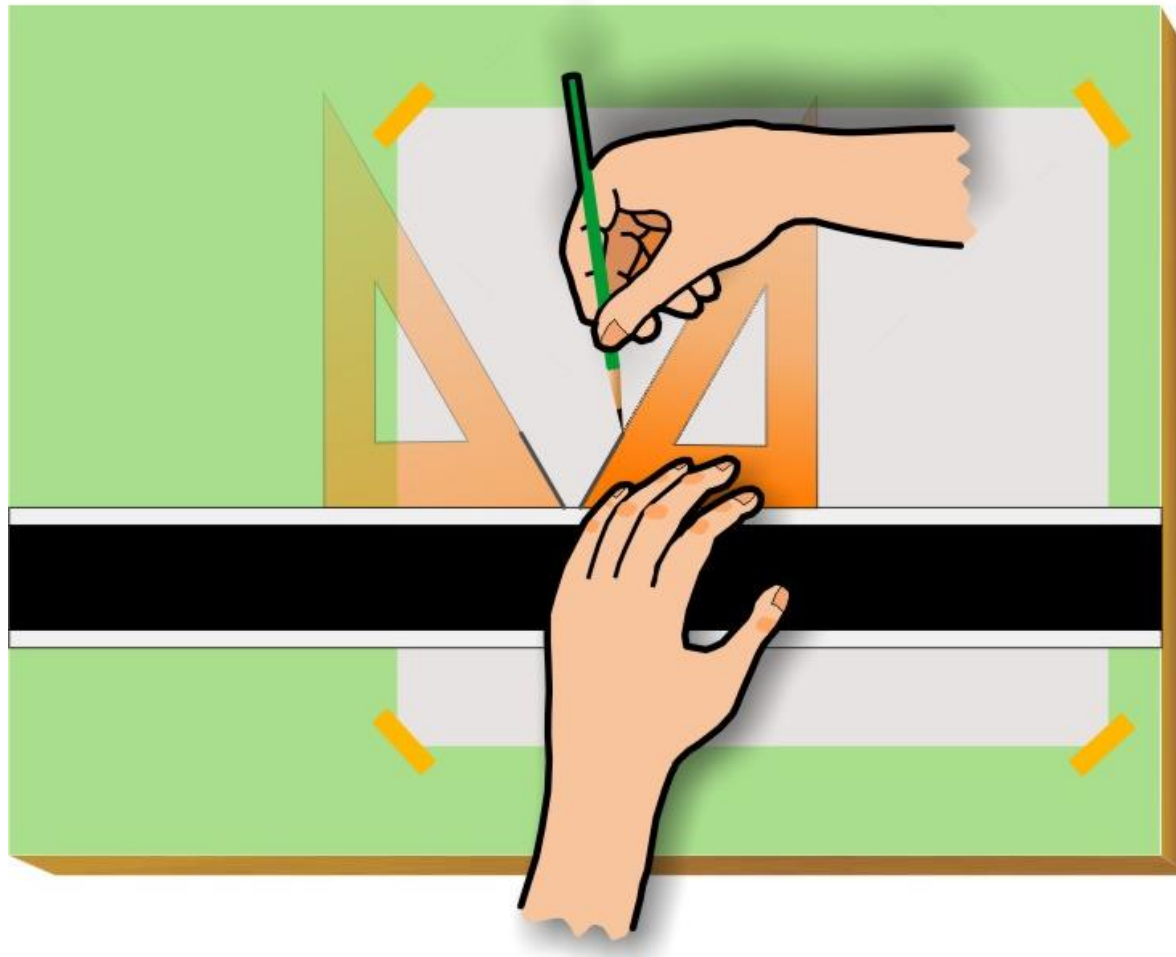
Placing the 30/60 triangle on the top of the straight-edge as in **Figure 3.11** allows you to draw lines 30 degrees from horizontal. These lines can be drawn either sloping to the right (as shown) or to the left by flipping the triangle over.

**Figure 3.11** Drawing Lines at 30 Degrees



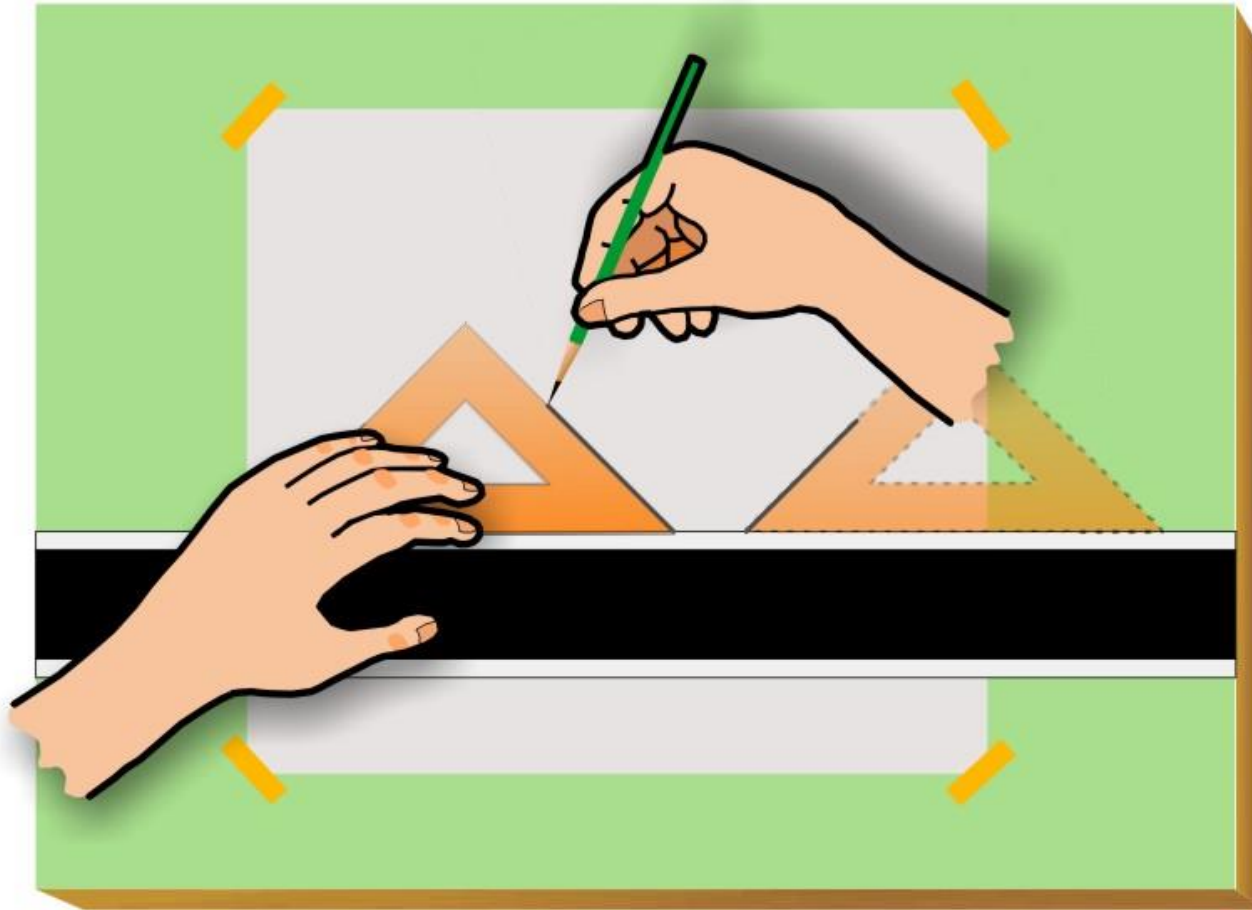
**Figure 3.12** shows lines being drawn at a 60 degree angle from horizontal. By flipping the triangle over, lines can be drawn sloping to the left or right as needed.

**Figure 3.12** Drawing Lines at 60 Degrees



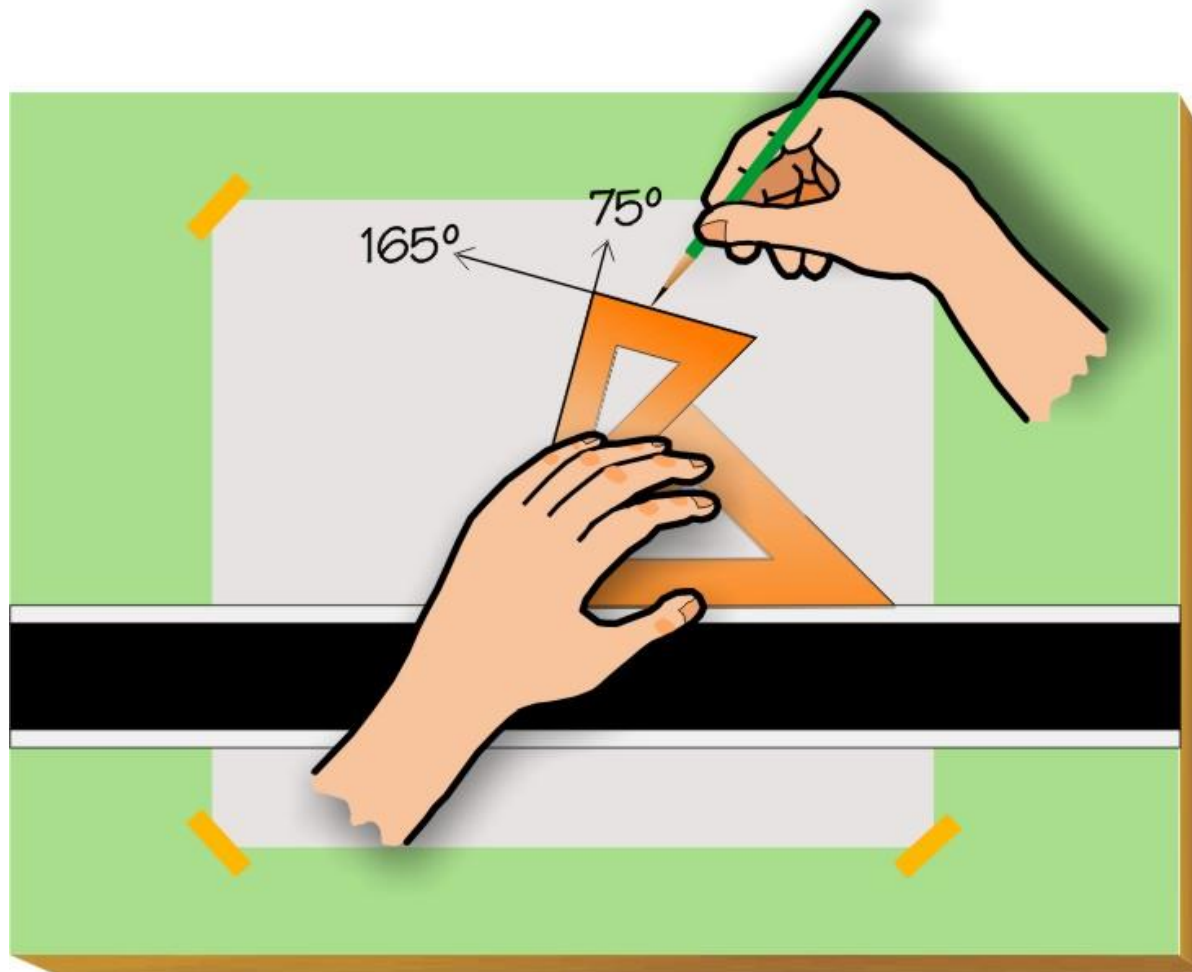
The 45 degree triangle can also be used to draw 45 degree lines sloping either to the left or right as in **Figure 3.13**.

**Figure 3.13** Drawing Lines at 45 Degrees



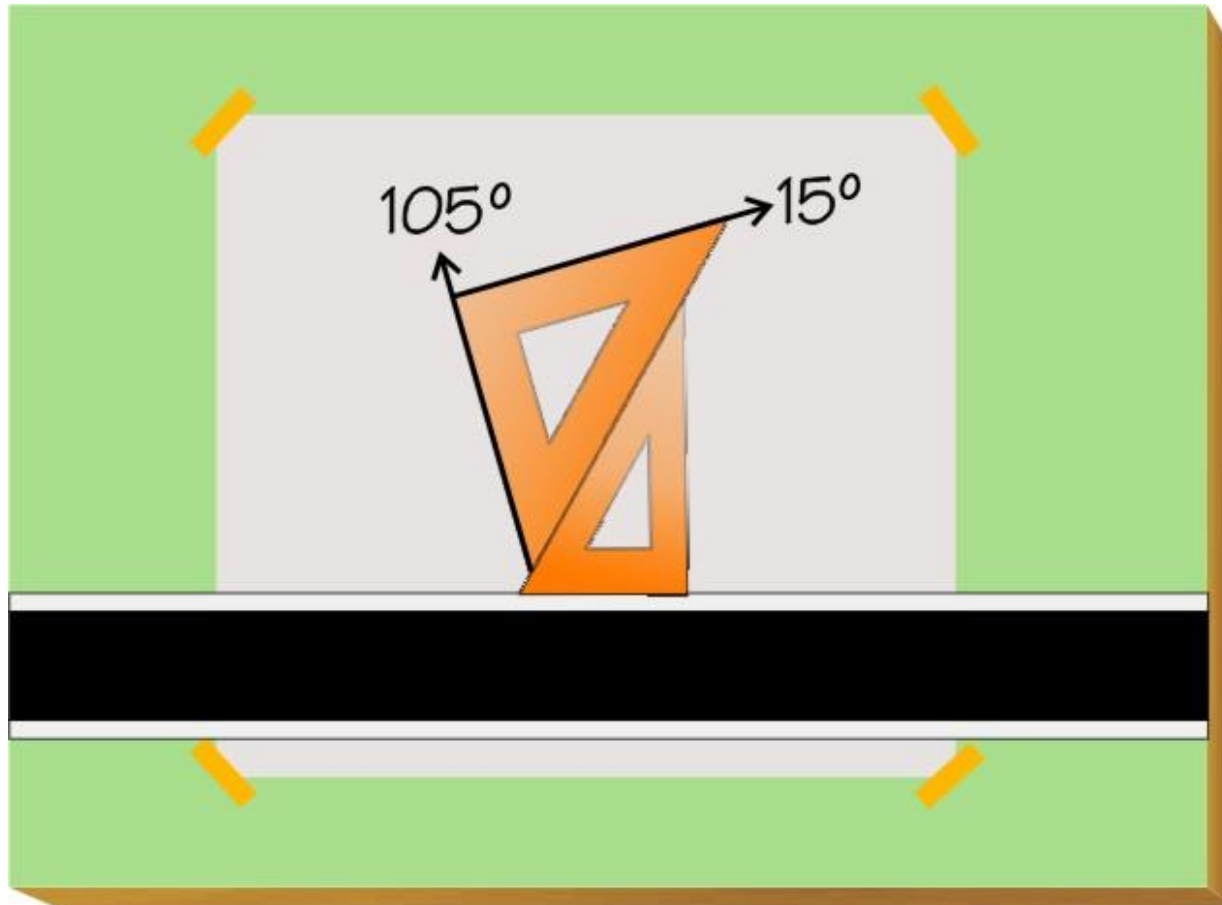
Using two triangles in combination allows you to draw lines at 15 degree increments. In **Figure 3.14**, the 45 and 30/60 triangles are combined to draw lines at 75 and 165 degrees.

**Figure 3.14** Combining Triangles to Produce Other Angles



In **Figure 3.15**, the 45 and 30/60 triangles are combined to draw lines at 105 and 15 degrees.

**Figure 3.15** Combining Triangles to Produce Other Angles



## Drawing Objects to Scale:

In technical drawings, objects are often drawn **to scale**. This term refers to the relationship between the size of the object in the drawing and the actual size of the object after it is manufactured. Below are four of the scales most commonly used in the creation of mechanical drawings:

**Full Scale**-this means that the size of the object in the drawing will be the same size as the object after it is manufactured. This is usually only feasible on smaller objects like machine parts (to draw an average size house at full scale you might need a sheet of paper that is 136 feet long by 88 feet wide). When noting on a drawing that the object is drawn full scale, the drafter could write  $1=1$ ,  $1/1$ , or  $1:1$ .

**Half Scale**-this means that the size of the object in the drawing is half the size of the object after it is manufactured. The drafter will still place the full size dimensions on the views of the object so that even though the drawing is half size, the part will be manufactured full size. When noting on a drawing that the object is drawn half scale, the drafter could write  $1=2$ ,  $1/2$ ,  $.5X$ , or  $1:2$ .

**Quarter Scale**-this means that the size of the object in the drawing is one fourth the size of the object after it is manufactured. The drafter will still place the full size dimensions on the views of the object so that even though the drawing is one fourth size, the part will be manufactured full size. When noting on a drawing that the object is drawn quarter scale, the drafter could write  $1=4$ ,  $1/4$ ,  $.25X$ , or  $1:4$ .

**Double Scale**-this means that the size of the object in the drawing is twice the size of the object after it is manufactured. The drafter will still place the full size dimensions on the views of the object so that even though the drawing is twice size, the part will be manufactured full size. This scale is used for smaller objects that would be difficult to dimension if drawn at actual size. When noting on a drawing that the object is drawn double scale, the drafter could write  $2=1$ ,  $2/1$ ,  $2:1$ , or  $2X$ .





## Making Measurements with the Engineer's, Architect's and Metric Scales

In engineering and architectural offices, designers and drafters use scales in two ways, the first is to take measurements off of existing drawings or plots and the second is to layout distances when constructing a drawing using traditional drafting techniques.

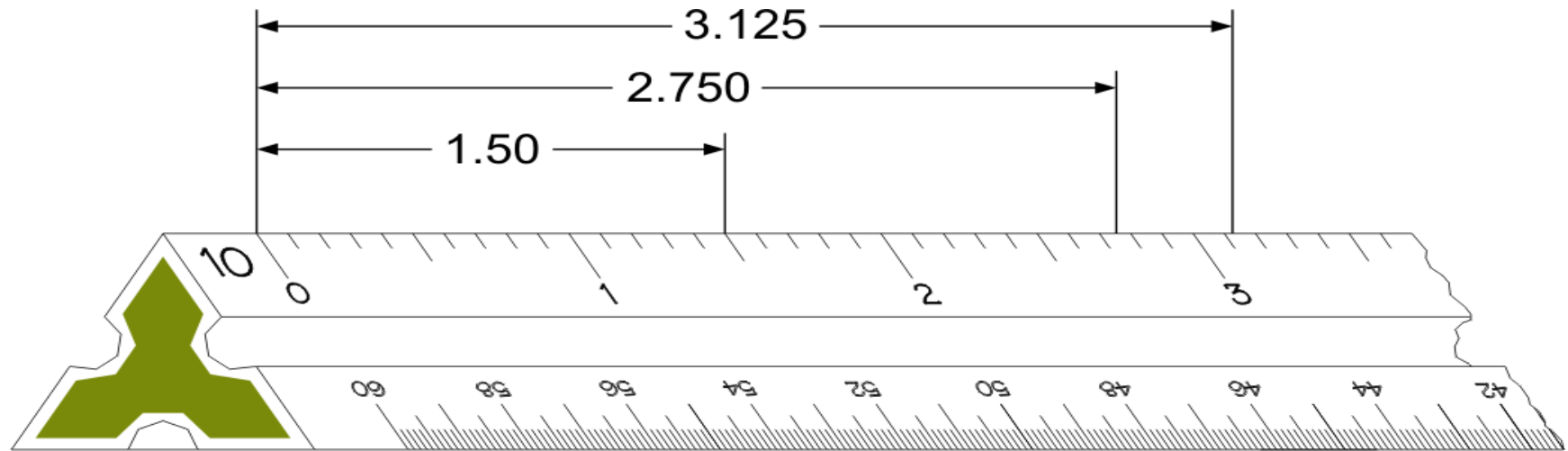
Depending on the type of drawing being created, a designer may choose either the **Engineer's**, **Architect's**, or **Metric** scales to measure distances (a **Combination** scale is also available that has a mix of the most commonly used scales).



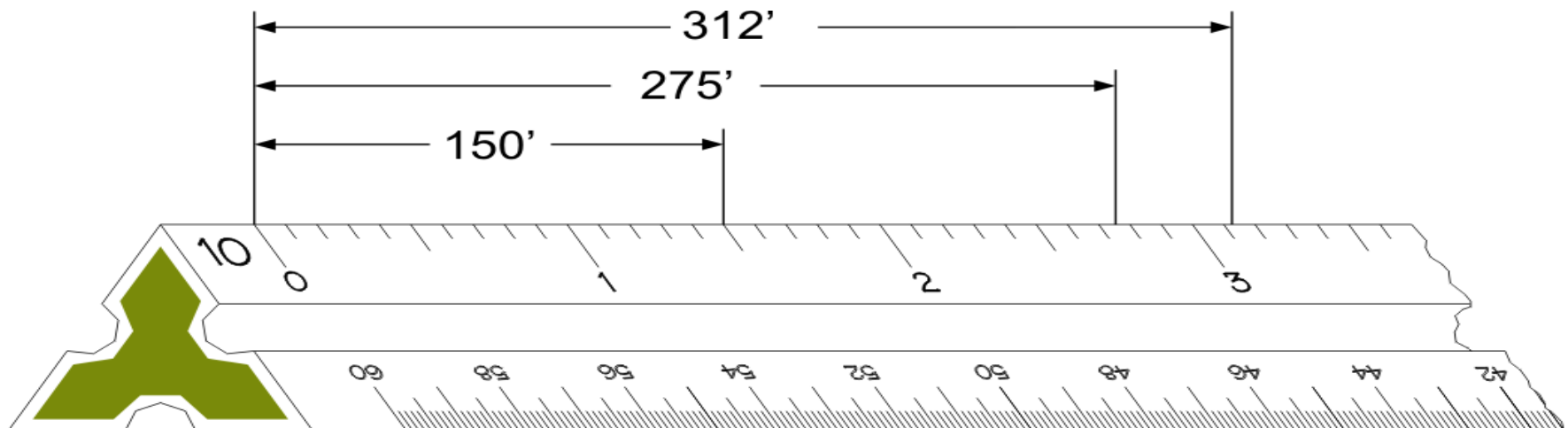
## Reading the Engineer's Scale

The Engineer Scale is used by both Mechanical and Civil engineers. The marks on the scale may be interpreted differently depending on the discipline. In **Figures 3.16** the Engineer's 10 scale is used to measure decimal inches. In **Figure 3.18** the Engineer's 10 scale is used to measure distances in feet.

**Figure 3.16** Measuring Decimal Inches with the Engineer's 10 Scale



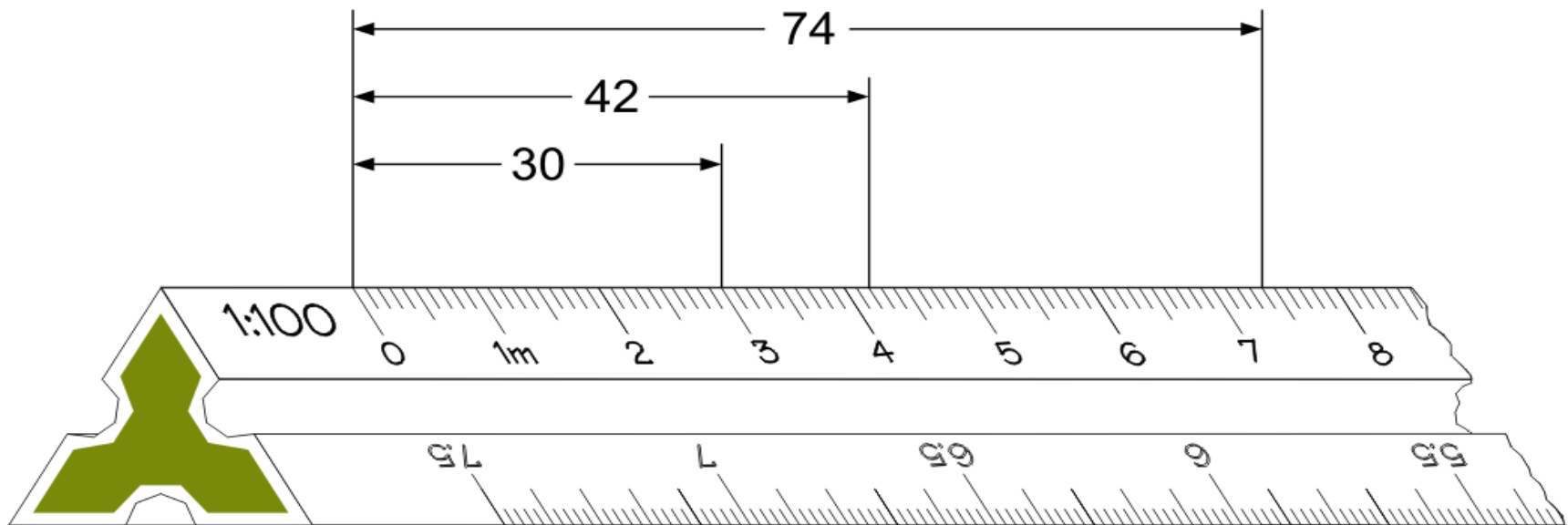
**Figure 3.17** Measuring Feet with the Engineer's 10 Scale-This Scale would be interpreted as 1"=100'



## Reading the Metric Scale

Mechanical engineers can use the **Metric scale** shown in **Figure 3.18** to measure distances in millimeters. In **Figure 3.18**, each small mark on the scale equals 1 millimeter.

**Figure 3.18** Measuring Millimeters with the Metric Scale



## Drawing Architectural Plans to Scale:

Below are two of the scales most commonly used in the creation of architectural drawings:

**1/4 Inch Equals 1 Foot**-this means that every 1/4 of an inch on the plotted drawing will represent a measurement of one foot on the actual construction project. For example a wall that is to be built 16 feet in length, will measure 4 inches on the drawing. This allows a drafter to fit a house that is 100 feet long and 50 feet wide on a sheet of paper measuring only 34 inches by 22 inches. The distance of 100 feet will measure only 25 inches on the drawing sheet ( $100 \times \frac{1}{4} = 25$ ) and 50 feet will measure 12.5 inches on the sheet ( $50 \times \frac{1}{4} = 12.5$ ). The dimensions on the drawing will be labeled at the actual distance (in feet and inches) required to construct the building full size. When noted on a drawing that the object is drawn to this scale, the drafter would write  $\frac{1}{4}'' = 1'-0''$ .

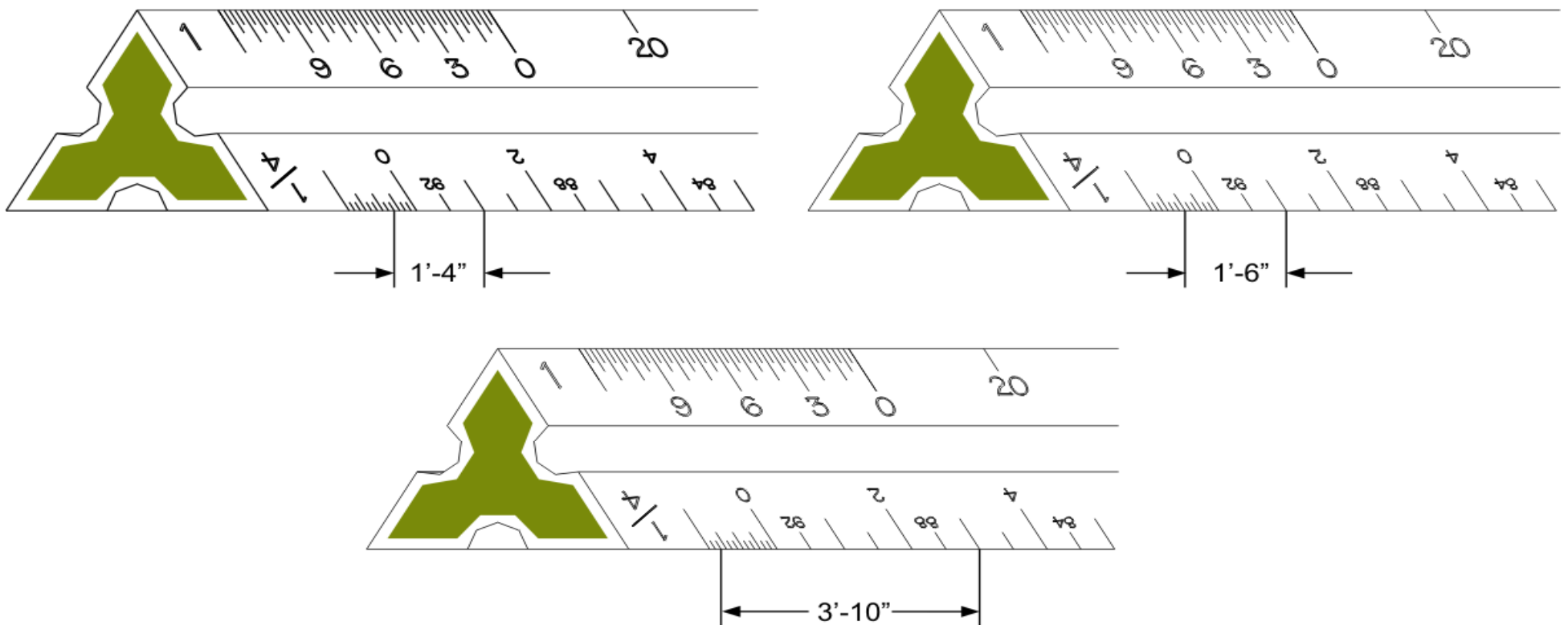
**1/8 Inch Equals 1 Foot**-this means that every 1/8 of an inch on the plotted drawing will represent a measurement of one foot on the actual construction project. For example a wall that is to be built 16 feet in length, will measure 2 inches on the drawing. This allows a drafter to fit a house that is 200 feet long and 100 feet wide on a sheet of paper measuring only 34 inches by 22 inches. The distance of 200 feet will measure only 25 inches on the drawing sheet ( $200 \times \frac{1}{8} = 25$ ) and 100 feet will measure 12.5 inches on the sheet ( $100 \times \frac{1}{8} = 12.5$ ). The dimensions on the drawing will be labeled at the actual distance (in feet and inches) required to construct the building full size. When noted on a drawing that the object is drawn to this scale, the drafter would write  $\frac{1}{8}'' = 1'-0''$ .



## Reading the Architect's Scale

The Architect's scale is used to measure feet and inches on a floor plan. The **Architect's 1/4** scale shown in **Figure 3.19** would be interpreted as  $1/4"=1'-0"$ . This means that  $1/4$  inch measured on the drawing would equal 1 foot at the construction site.

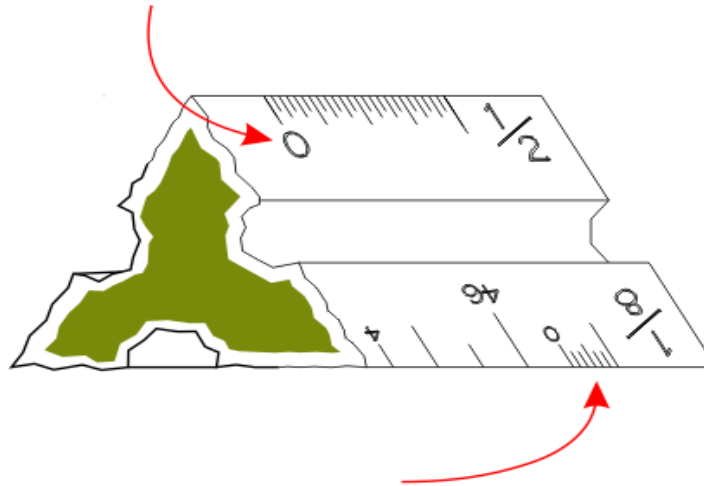
**Figure 3.19** Reading Feet and Inches on the Architect's  $1/4"$  equals 1' Scale



**Figures 3.20, 3.21, and 3.22** show examples of other commonly used architectural scales.

**Figure 3.20** Interpreting Inch Marks on the Architect's 1/2 and 1/8 scales

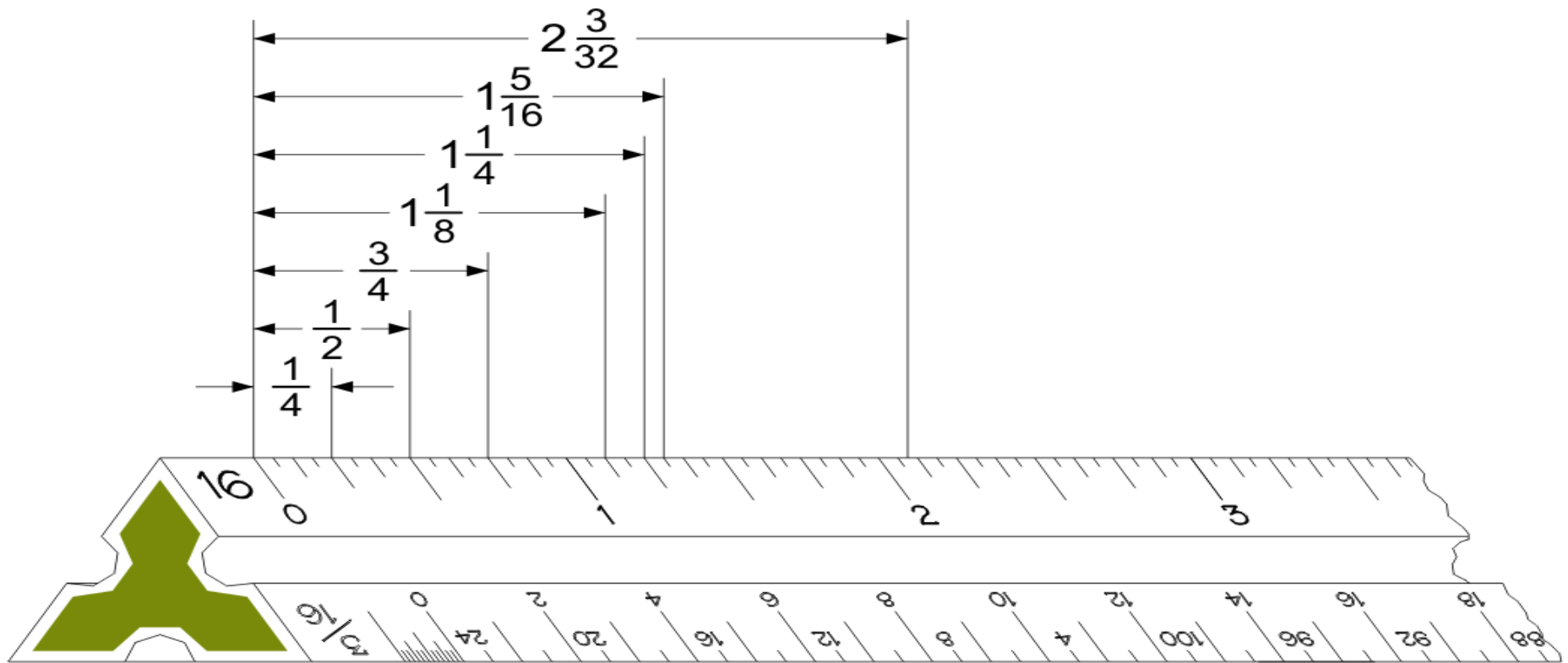
The secret to using these scales is to align the numbers with the zero. Once you have done this it becomes relatively easy to determine the required ticks for measuring.



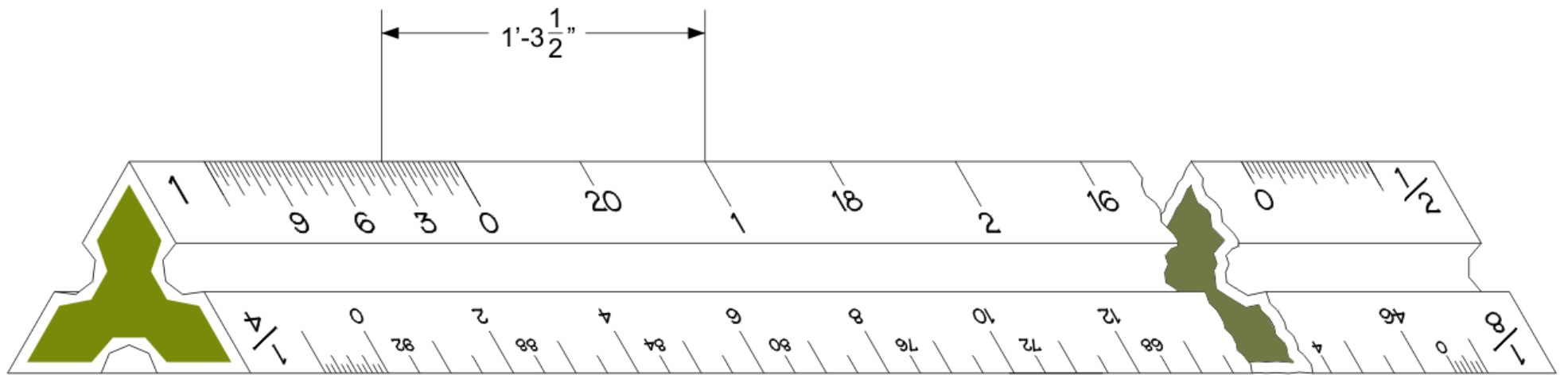
Each mark on the 1/8th scale is worth two inches (2,4,6,8, etc.)



**Figure 3.21** Measuring Fractional Inches with the Architect's 16 Scale



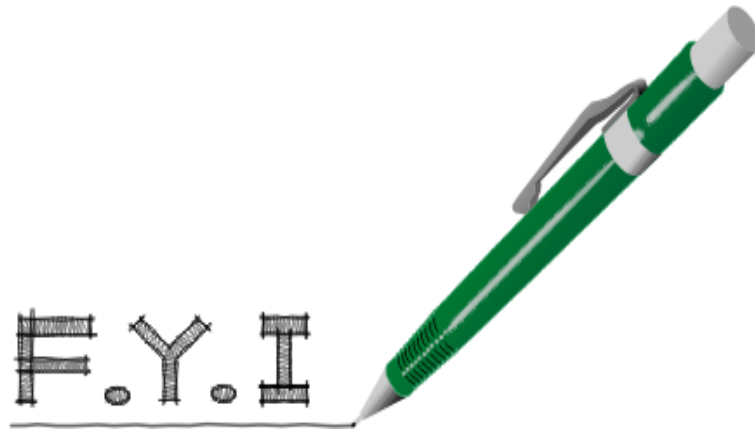
**Figure 3.22** Measuring Feet and Inches with the Architect's 1"=1'-0" Scale



The scale along this edge - if read from the right - would be 1/8"=1'-0







To avoid having to search for a desired scale on a triangular scale use a binder clip to mark your scale. For example: If using the 10 scale on an Engineers scale, attach the binder clip to the 50 scale. When you pick up your scale the binder clip will orient you to the 10 scale.



# Converting Units of Measurement

Sometimes, drafters must convert from one unit of measurement to another. Some commonly used conversion factors are listed below:

- Fractional inches can be converted to decimal inches by dividing the numerator (the top number) by the denominator (the bottom number)
- Decimal inches can be converted to millimeters by multiplying them by 25.4
- Millimeters can be converted to decimal inches by dividing them by 25.4

**Table 3.2** is useful for quickly finding the equivalent value between the various units listed.

**Table 3.2** Converting Fractional Inches, Decimal Inches and Millimeters.

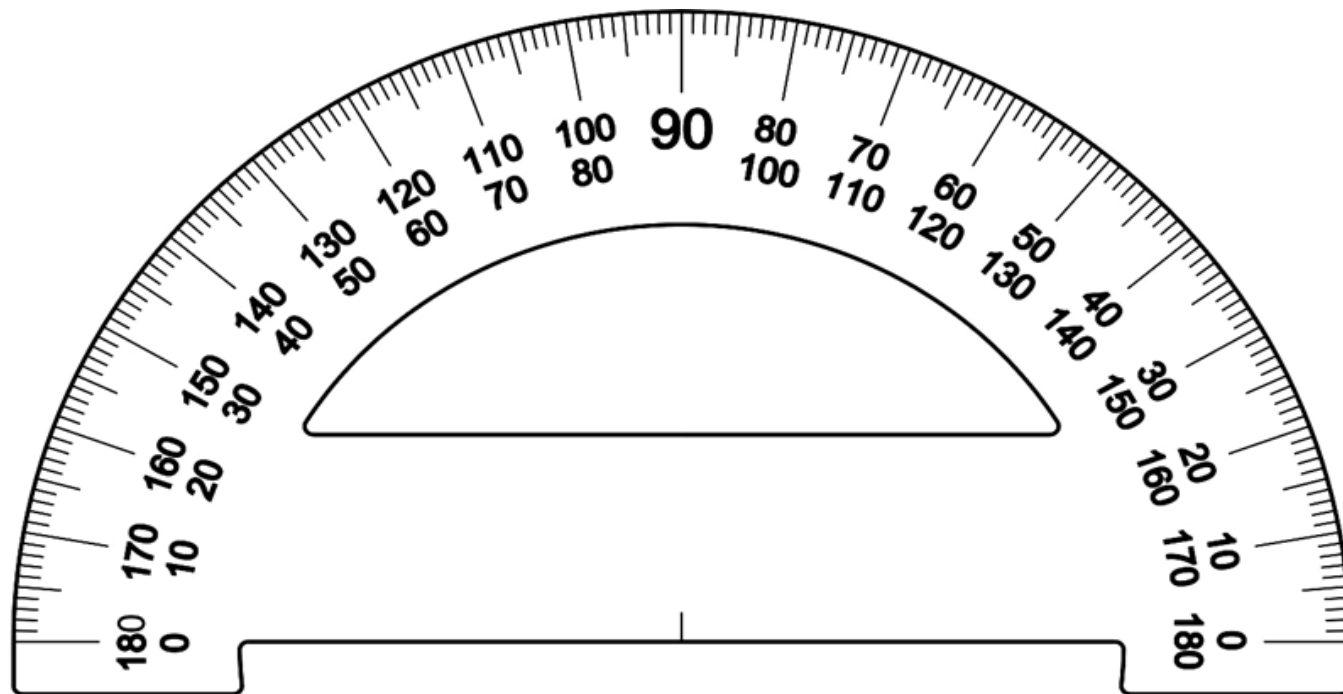
Fractional Inch	Decimal Inch	Metric (mm)	Fractional Inch	Decimal Inch	Metric (mm)
1/64	.015625	0.3969	33/64	.515625	13.0969
1/32	.03125	0.7938	17/32	.53125	13.4938
3/64	.046875	1.1906	35/64	.546875	13.8906
1/16	.0625	1.5875	9/16	.5625	14.2875
5/64	.078125	1.9844	37/64	.578125	14.6844
3/32	.09375	2.3813	19/32	.59375	15.0813
7/64	.109375	2.7781	39/64	.609375	15.4781
1/8	.1250	3.1750	5/8	.6250	15.8750
9/64	.140625	3.5719	41/64	.640625	16.2719
5/32	.15625	3.9688	21/32	.65625	16.6688
11/64	.171875	4.3656	43/64	.671875	17.0656
3/16	.1875	4.7625	11/16	.6875	17.4625
13/64	.203125	5.1594	45/64	.703125	17.8594
7/32	.21875	5.5563	23/32	.71875	18.2563
15/64	.234375	5.9531	47/64	.734375	18.6531
1/4	.250	6.3500	3/4	.750	19.0500
17/64	.265625	6.7469	49/64	.765625	19.4469
9/32	.28125	7.1438	25/32	.78125	19.8438
19/64	.296875	7.5406	51/64	.796875	20.2406
5/16	.3125	7.9375	13/16	.8125	20.6375
21/64	.328125	8.3344	53/64	.828125	21.0344
11/32	.34375	8.7313	27/32	.84375	21.4313
23/64	.359375	9.1281	55/64	.859375	21.8281
3/8	.3750	9.5250	7/8	.8750	22.2250
25/64	.390625	9.9219	57/64	.890625	22.6219
13/32	.40625	10.3188	29/32	.90625	23.0188
27/64	.421875	10.7156	59/64	.921875	23.4156
7/16	.4375	11.1125	15/16	.9375	23.8125
29/64	.453125	11.5094	61/64	.953125	24.2094
15/32	.46875	11.9063	31/32	.96875	24.6063
31/64	.484375	12.3031	63/64	.984375	25.0031
1/2	.500	12.700	1	1.000	25.400



## Reading the Protractor

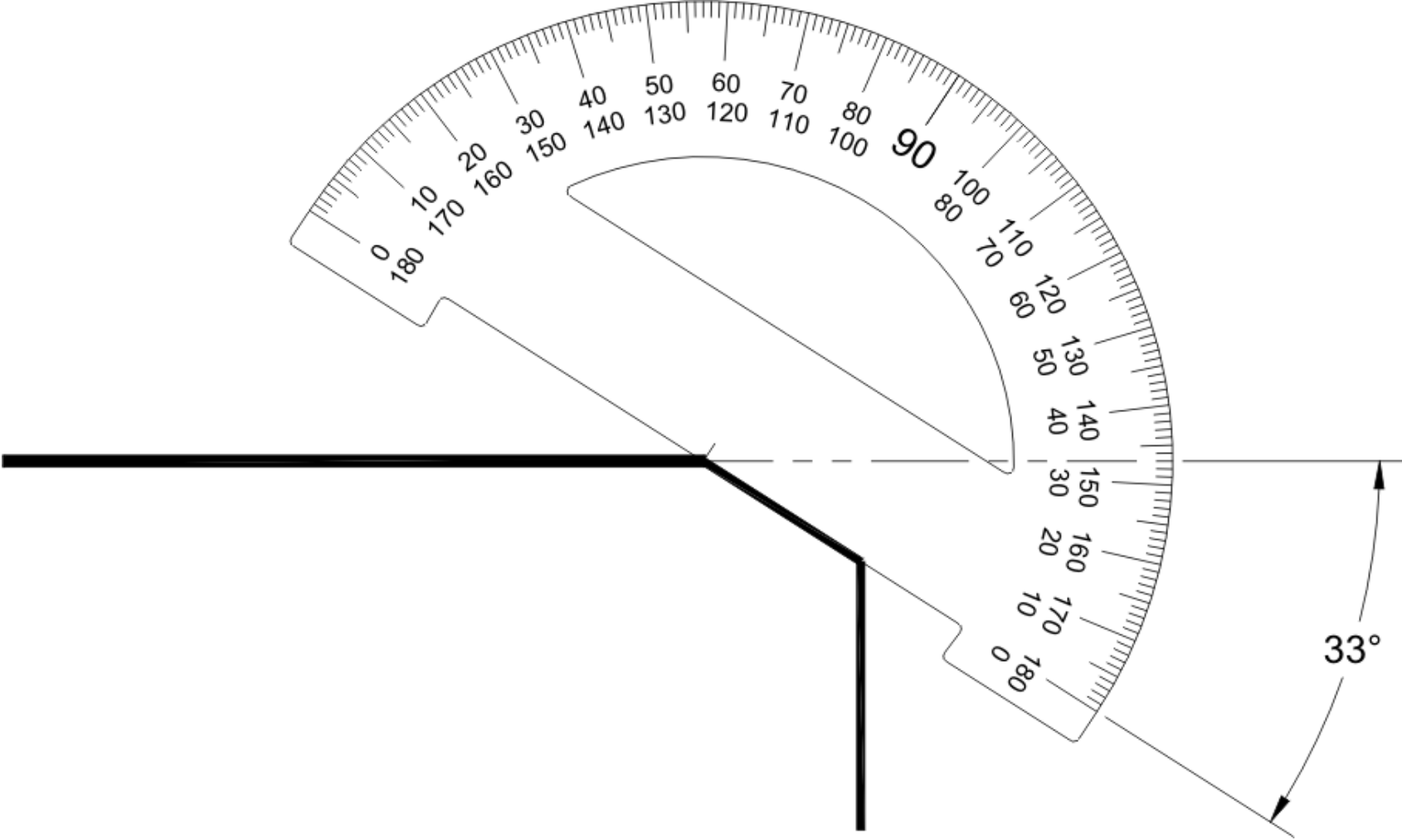
A protractor is a tool used to layout angles on a drawing. Full circle protractors are divided into 360 degrees while half moon protractors (see **Figure 3.23**) are divided into 180 degrees. Both are divided in 10 degree increments. Note how the protractor is divided from 0 to 180 degrees both clockwise and counter-clockwise.

**Figure 3.23** A Half-moon, or 180 Degree, Protractor.



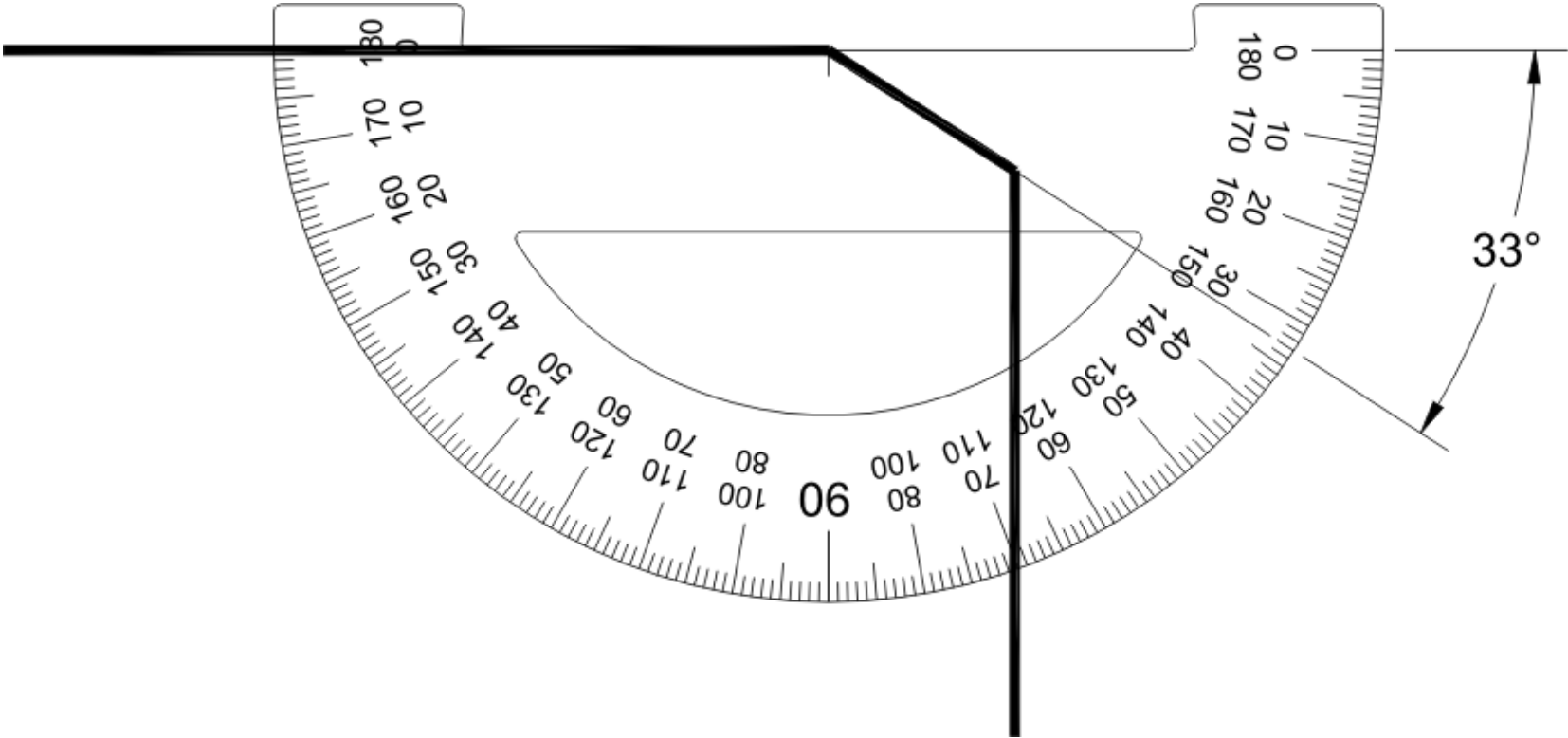
Figures 3.24 through 3.27 illustrate some of the ways the protractor can be used to measure angles.

Figure 3.24 A 33° Angle Using the Inner Dial.

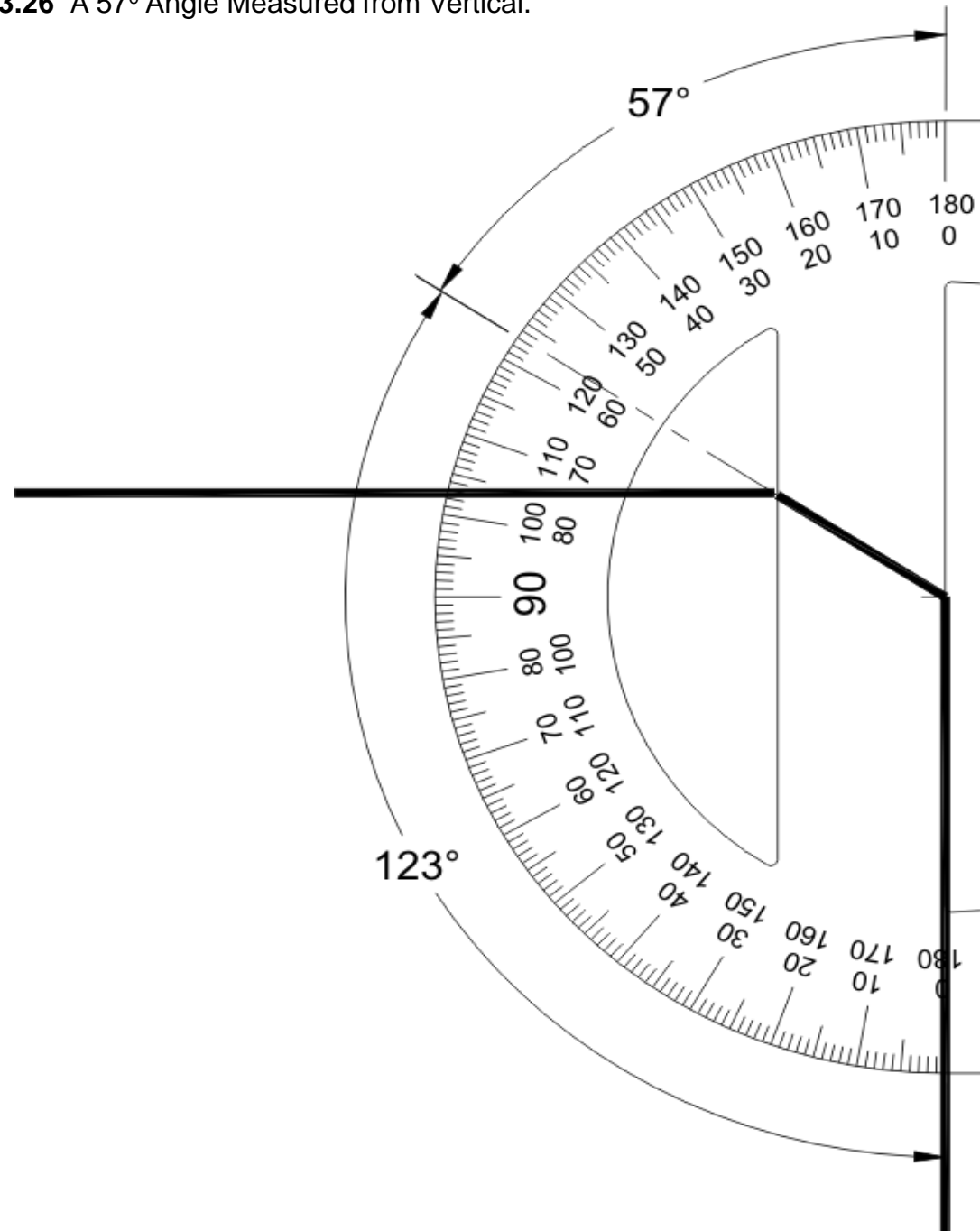


Figures 3.24 through 3.27 illustrate some of the ways the protractor can be used to measure angles.

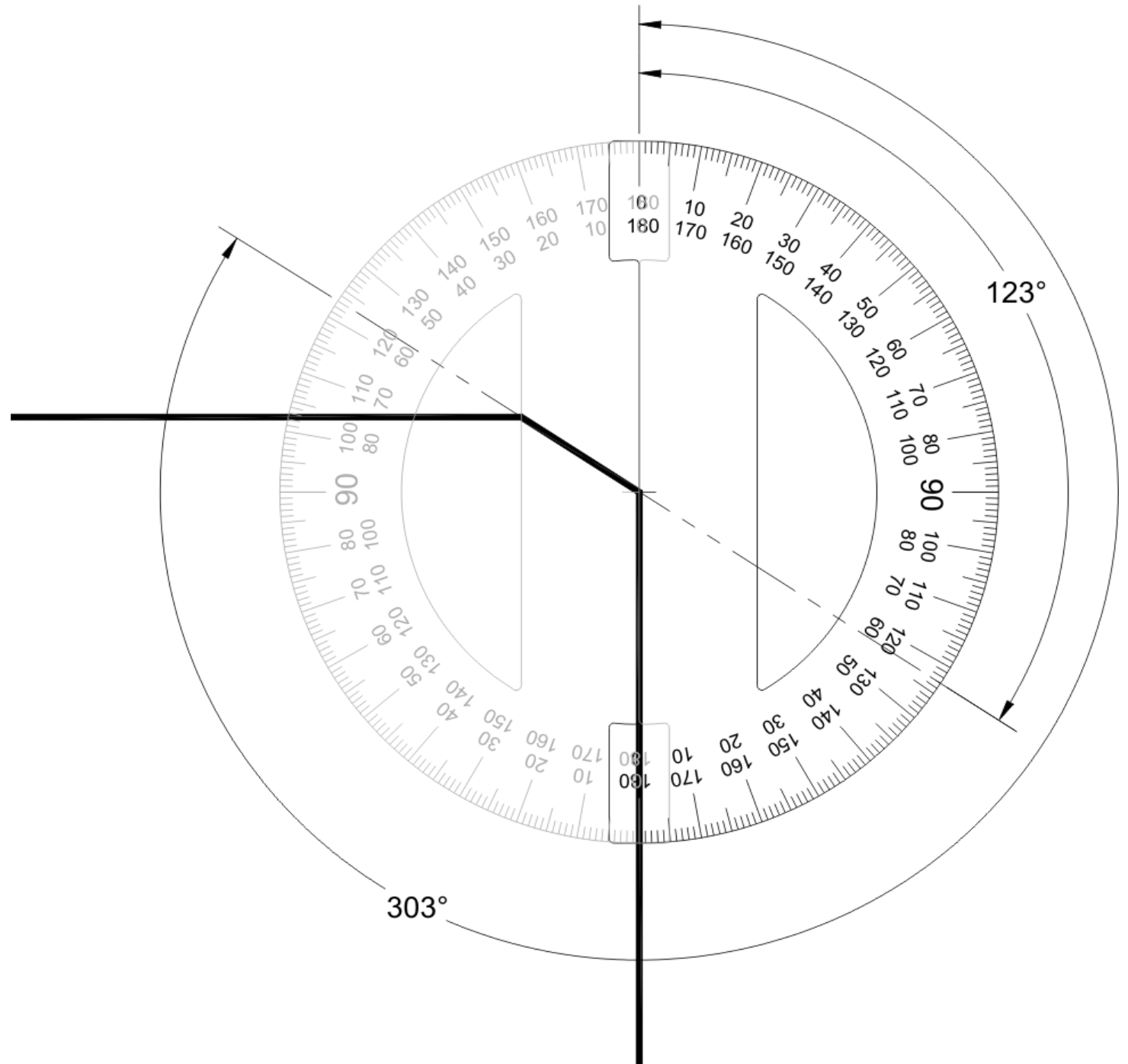
Figure 3.25 A 33° Angle Using the Outer Dial.



**Figure 3.26** A  $57^\circ$  Angle Measured from Vertical.



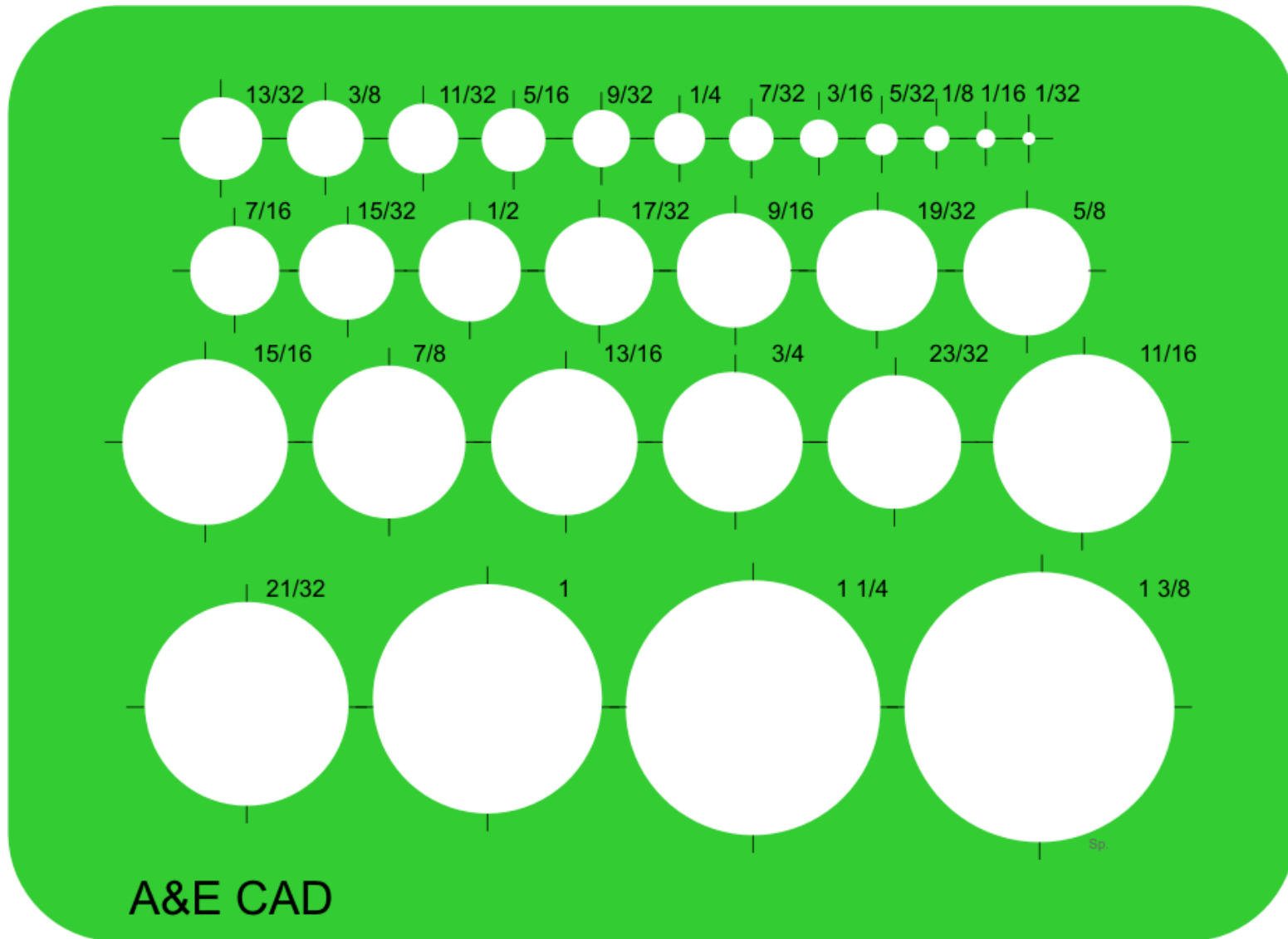
**Figure 3.27** Measuring an Angle Greater than 180° using a Half-moon Protractor.



# The Circle Template

Circle templates come in a wide range of units-decimal inches, fractional inches and millimeters-and diameters.

**Figure 3.28** A Circle Template.

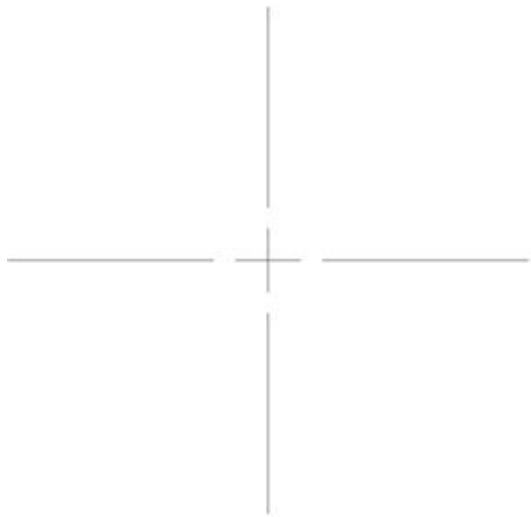




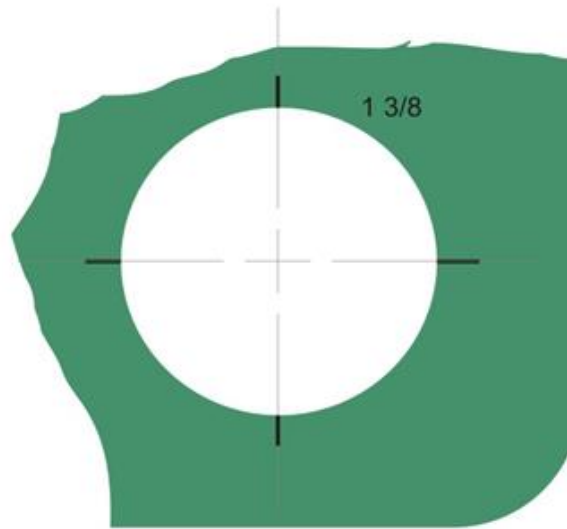
# The Circle Template-Continued

**Figure 3.29** Using the Circle Template.

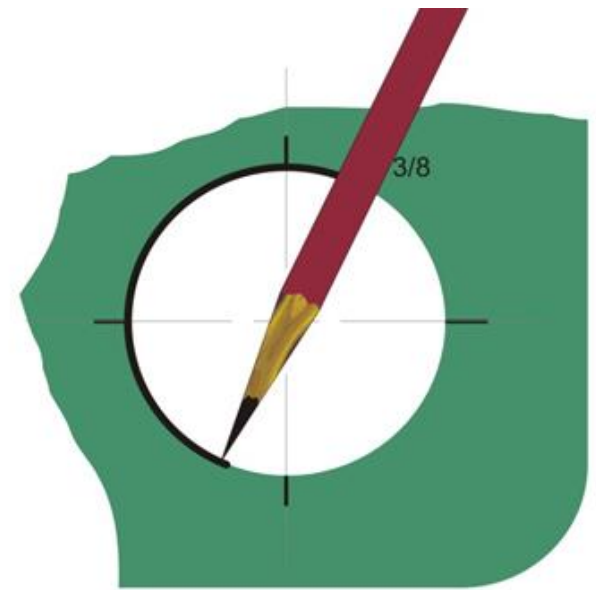
1. Locate center and draw crosshair.



2. Find the desired circle size and align the ticks on the template with the crosshair.



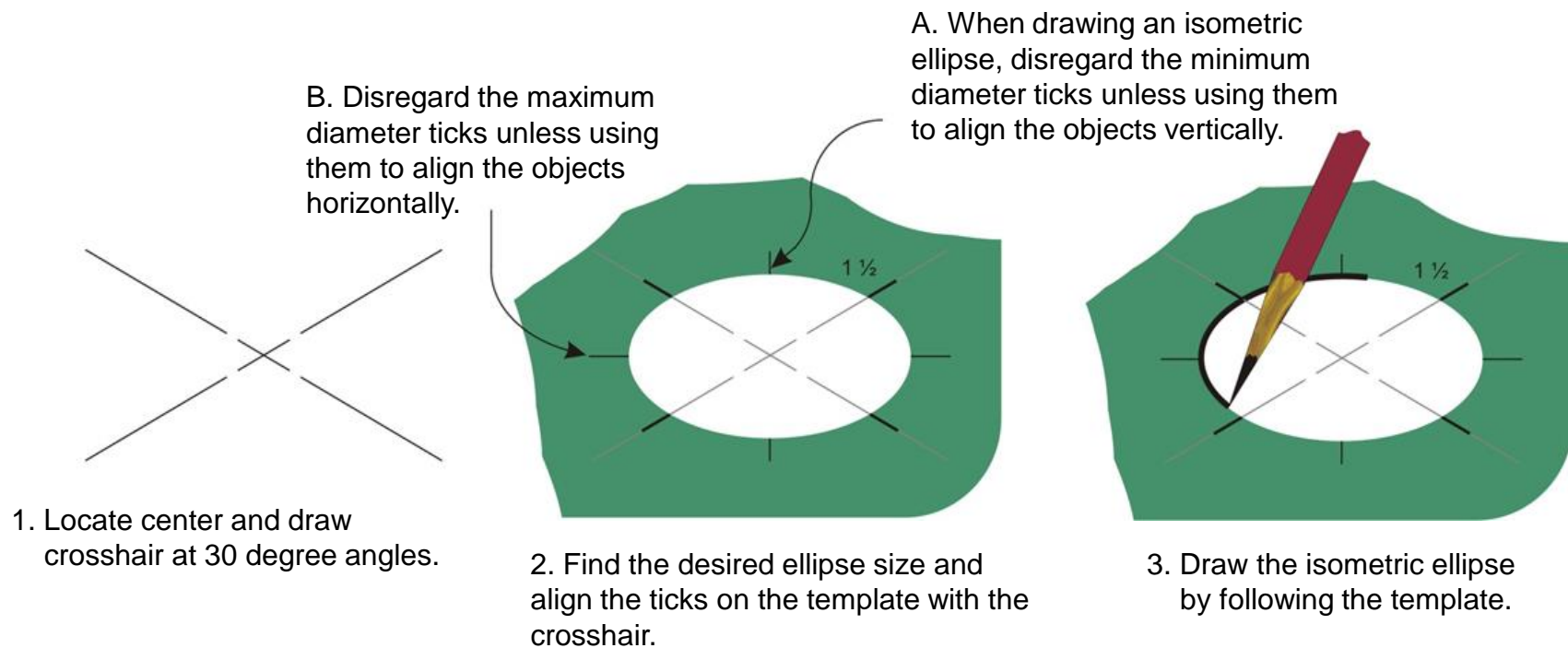
3. Draw the circle by following the template.



## The Isometric Ellipse Template

On isometric drawings, circles are represented as ellipses. Isometric ellipse templates allow drafters to quickly place ellipses on isometric drawings.

**Figure 3.30** Using an Isometric Ellipse Template.



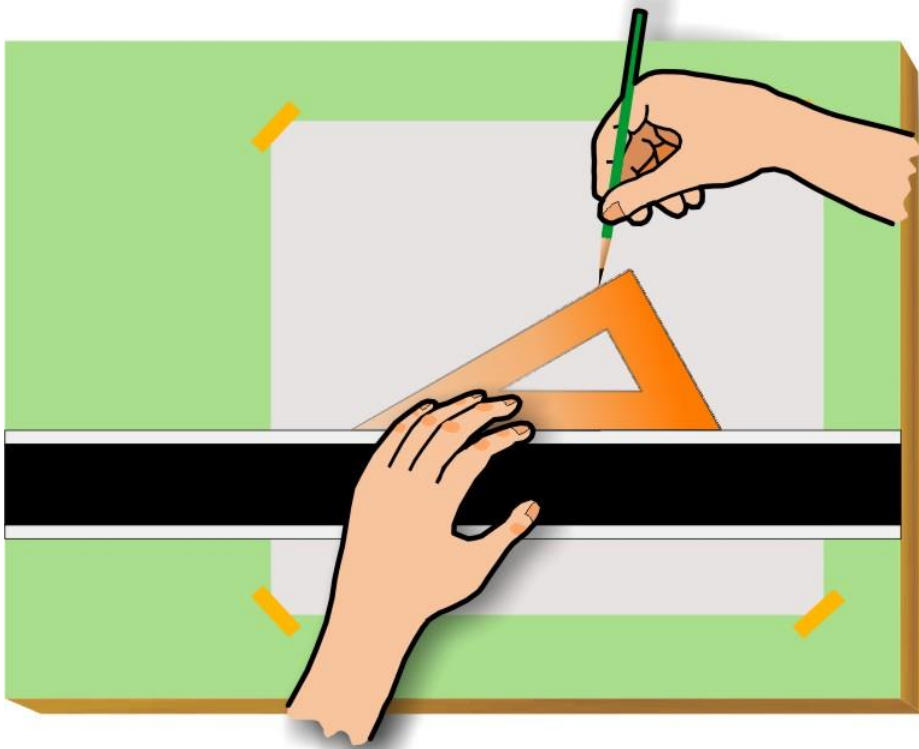
## Steps in Constructing a Simple Drawing

Steps 1 through 9 illustrate how a drafter may use the triangle, scale, and parallel straight-edge to construct a simple technical drawing. At the end of this unit are drafting projects in which you will have an opportunity to apply the techniques shown in these steps.

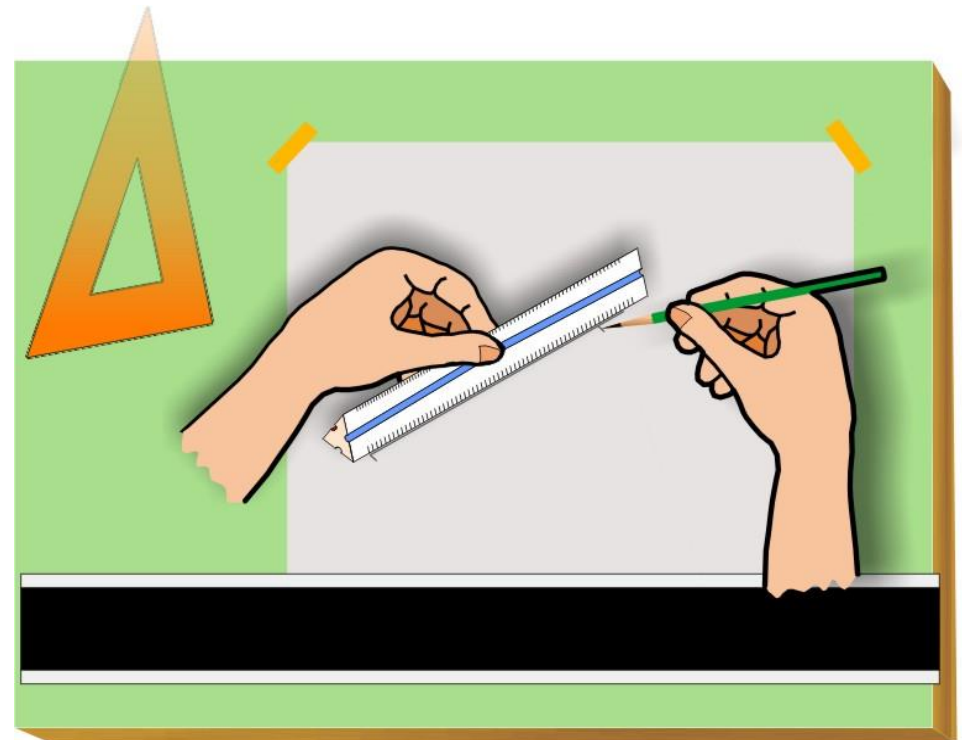
**Step 1.** Draw a 30 degree construction line. See **Figure 3.31**.

**Step 2.** Align the scale along the construction line and place light “tick marks” to denote the desired measurement as shown in **Figure 3.32**.

**Figure 3.31** Drawing a Light Construction Line

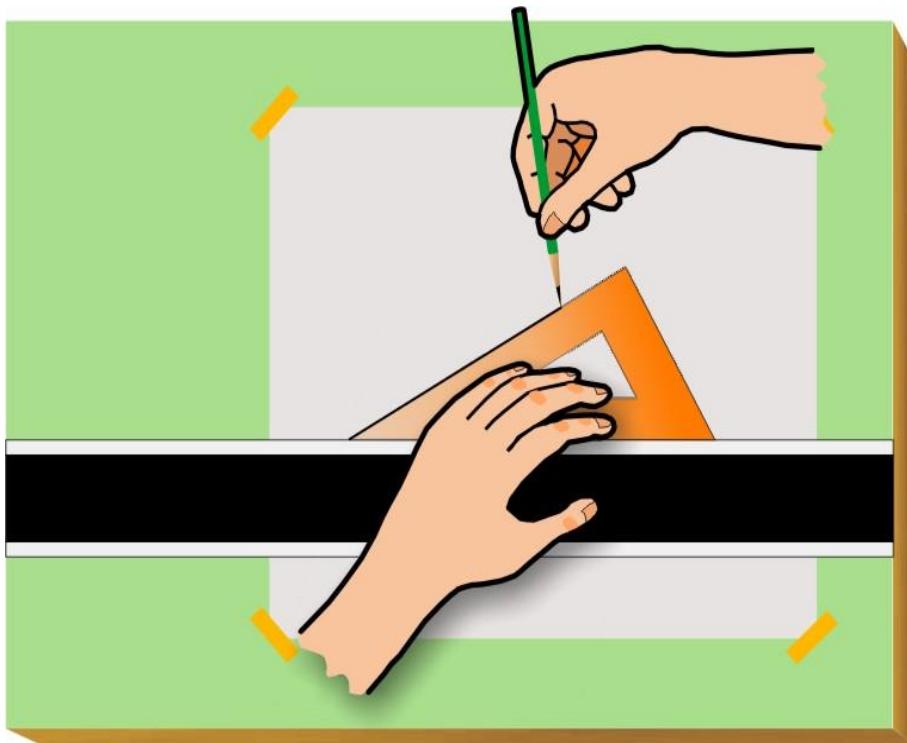


**Figure 3.32** Marking the Desired Length with Light Tick Marks



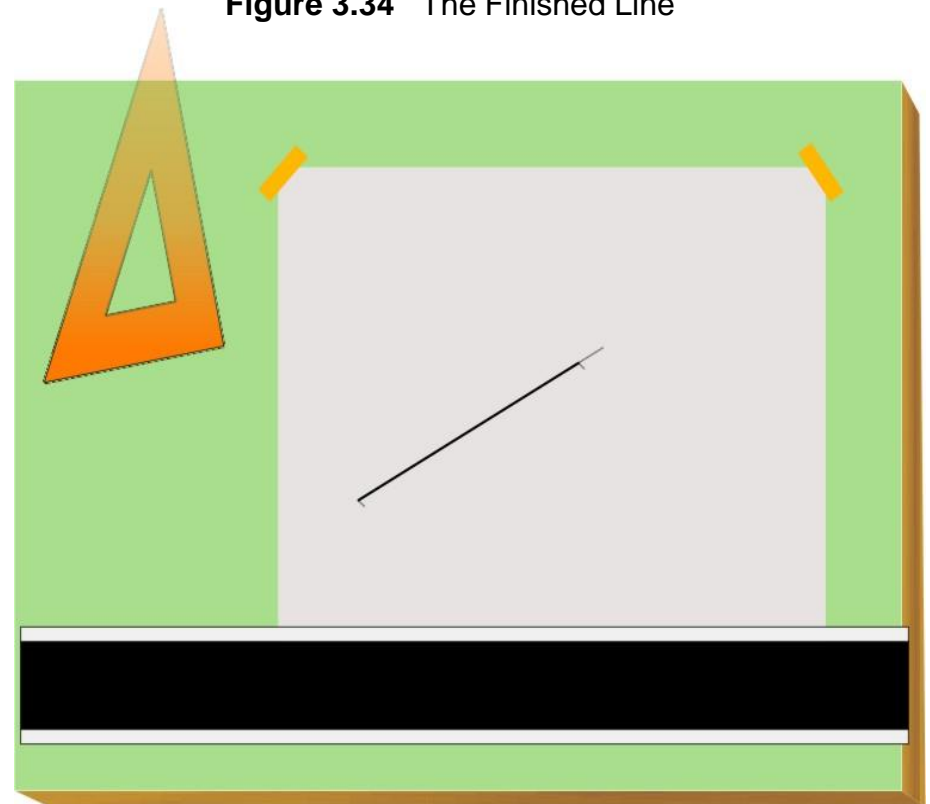
**Step 3.** Align the edge of the 30-60 triangle with the construction line and draw a dark visible line along the top edge of the triangle between the tick marks. See Figure 3.33.

**Figure 3.33** Darkening the Line Between the Tick Marks



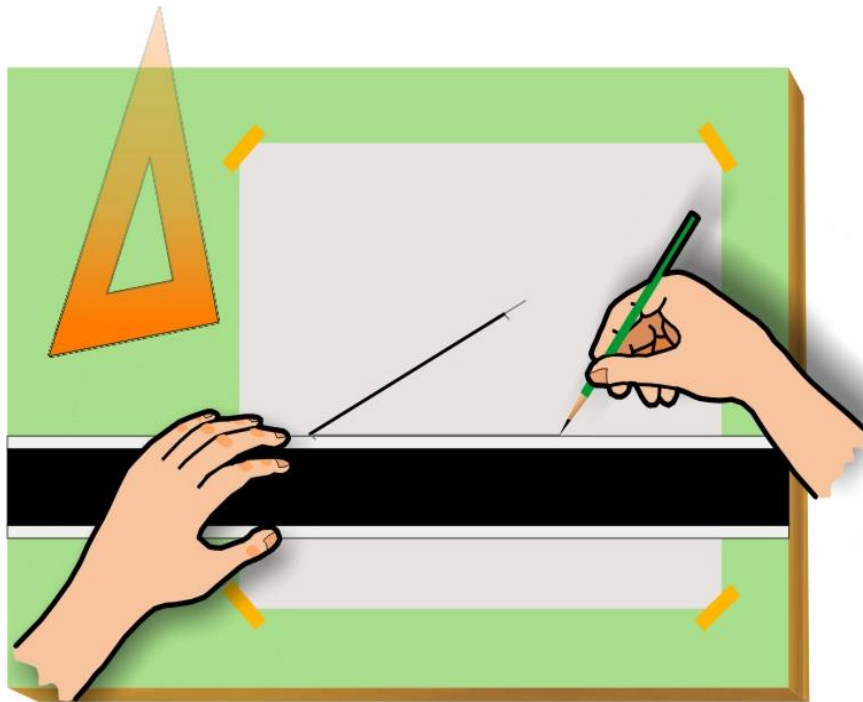
**Step 4.** The darkened visible line is drawn the desired distance as shown in **Figure 3.34**.

**Figure 3.34** The Finished Line



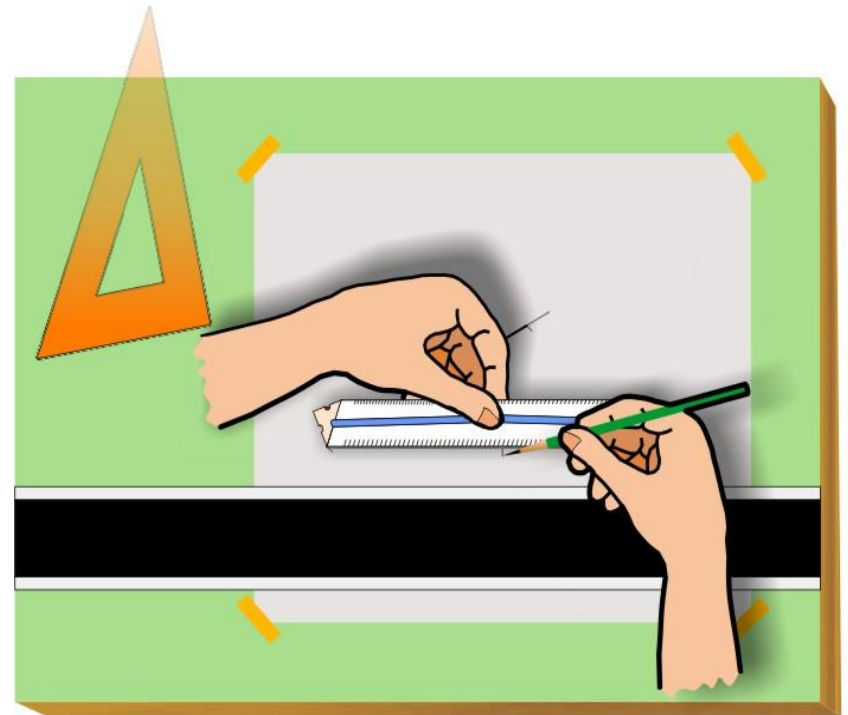
**Step 5.** Slide the straight-edge until it is aligned with the lower end of the darkened line and lightly draw a horizontal construction line. See **Figure 3.35**.

**Figure 3.35** Drawing a Horizontal Construction Line



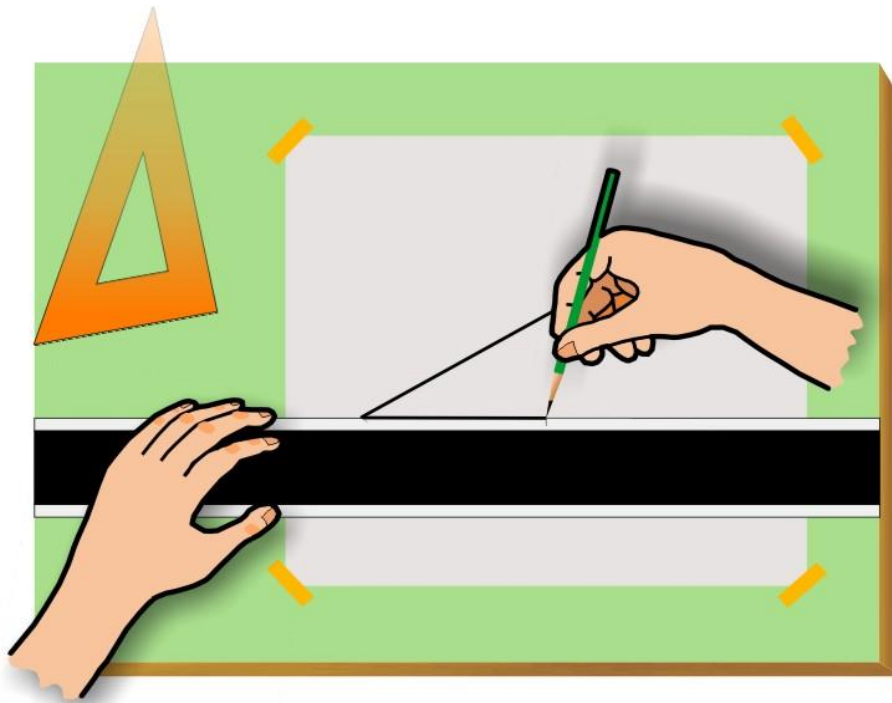
**Step 6.** Measure the along the horizontal construction line with the scale and mark off the desired distance with a small tick mark. See **Figure 3.36**.

**Figure 3.36** Using a Scale to Make a Measurement on the Horizontal Line



**Step 7.** Draw a dark visible line between the tick marks. See **Figure 3.37**.

**Figure 3.37** Darkening the Horizontal Line



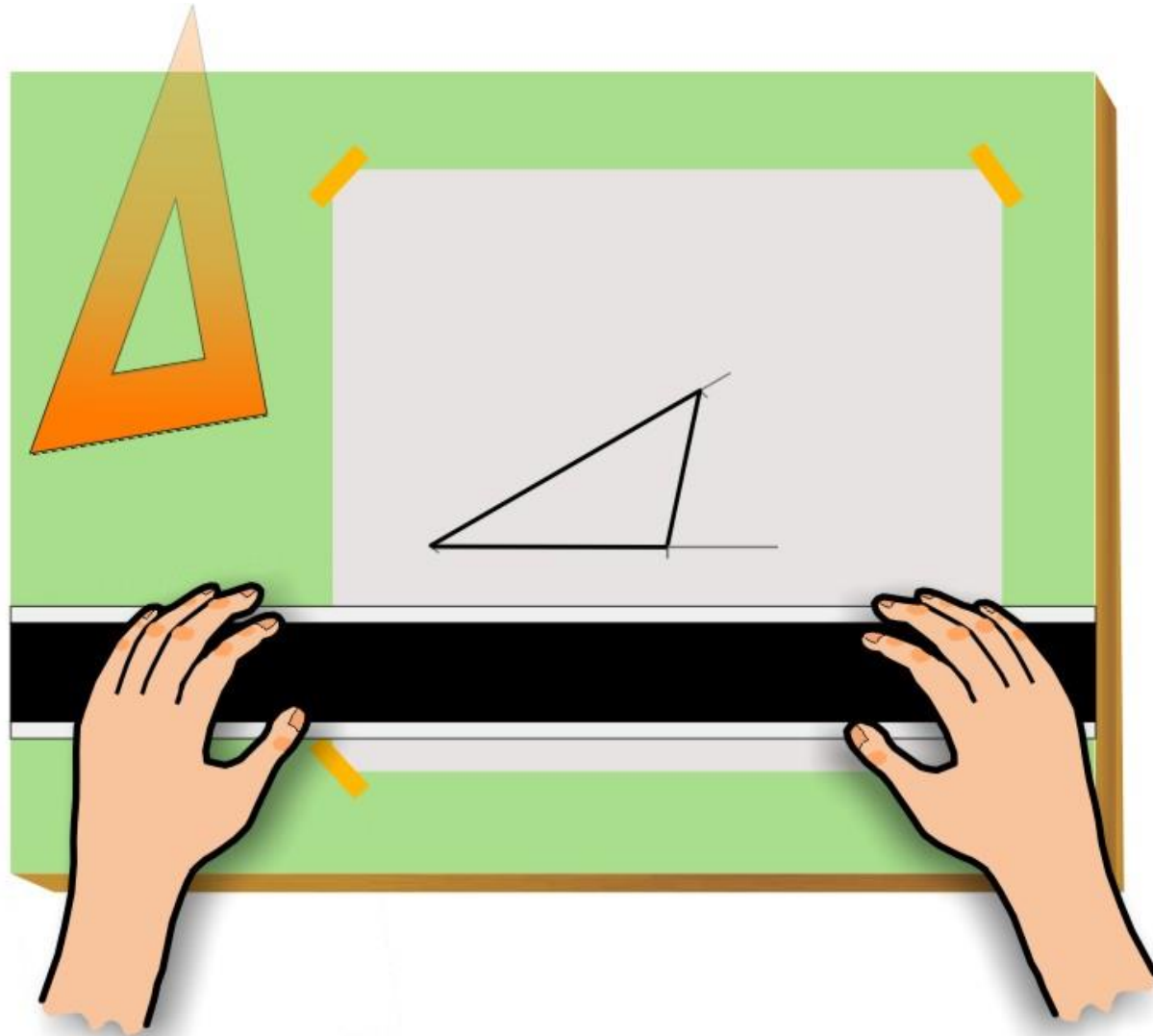
**Step 8.** Because the angle between the ends of the lines does not match an angle on either triangle, **float** the triangle until it is aligned with the ends of each line and draw a dark visible line connecting them. See **Figure 3.38**.

**Figure 3.38** Floating the Triangle to Connect the Endpoints of the Lines



The completed drawing is shown in **Figure 3.39**.

**Figure 3.39** The Finished Drawing



# Drawing Sheet Sizes

Drafters create drawings on standardized sheet sizes. Sheet size varies with the type of drawing and/or the unit of measurement used to create the drawing.

For Mechanical drawings, where inches are used as the unit of measurement, the standard sheet sizes begin with an **A** size sheet which is 11 X 8.5 inches. A **B** size sheet's dimensions are 17 X 11 which is the equivalent of two **A** sheets laid side by side. A **C** size sheet is 22 X 17 which is the equivalent of two **B** sheets laid side by side. A **D** size sheet is 34 X 22 which is the equivalent of two **C** sheets laid side by side. The American Society of Mechanical Engineers standard for **Decimal Inch Drawing Sheet Size and Format** is **ASME Y14.1 – 2005**. **Figure 2.45** illustrates the sheet sizes used in mechanical drawings employing the decimal inch sheet format.

For Mechanical drawings where millimeters are used as the unit of measurement, an **A4** sheet measures 297 X 210, an **A3** sheet measures 420 X 297, an **A2** sheet measures 594 X 420, and an **A1** sheet measures 841 X 594. The American Society of Mechanical Engineers standard for **Metric Drawing Sheet Size and Format** is **ASME Y14.1M - 2005**.

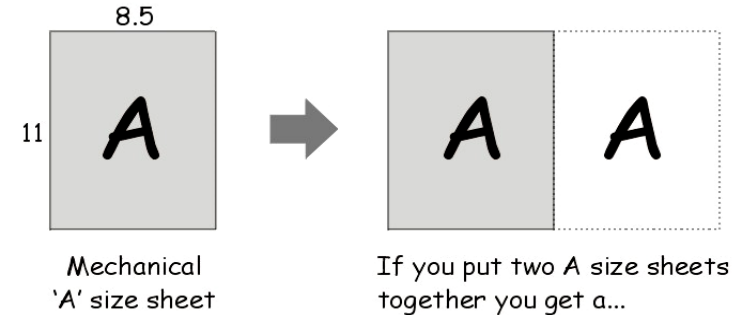
For Architectural drawings where inches are used as the unit of measurement, an **A** sheet measures 12 X 9 inches, a **B** sheet is 18 X 12, a **C** sheet is 24 X 18, and a **D** sheet is 36 X 24.

A high-quality paper known as vellum, or tracing paper, is used to plot drawings that are intended to be reproduced using the blueprinting process (more accurately known as blue-line prints). Vellum is a strong, thin paper that allows light to pass through it relatively easily. In order to reproduce a drawing using the blue-line process, light must be able to pass through the paper the original is drawn on.

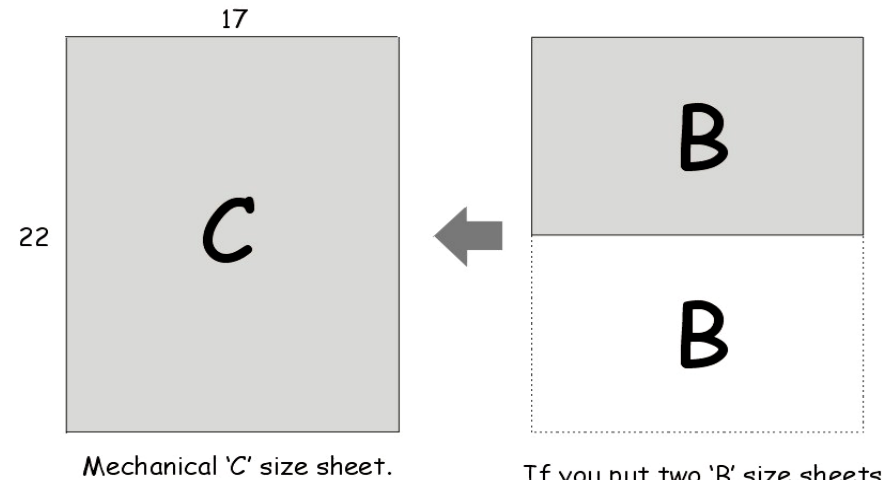
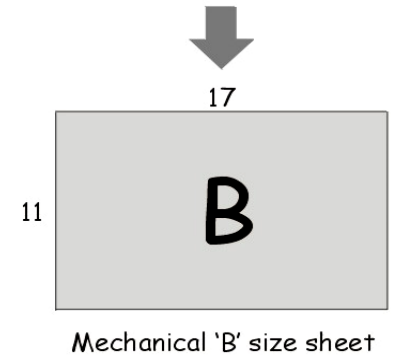
Vellum can be purchased in rolls 24" to 36" in width, or in standard sheet sizes. Vellum can also be purchased with pre-printed title blocks.

**Figure 2.45** Sheet Sizes for Mechanical Drawings

## Sheet Sizes and Drawing Limits Mechanical



**Figure 2.48**  
Sheet sizes for a mechanical drawing.



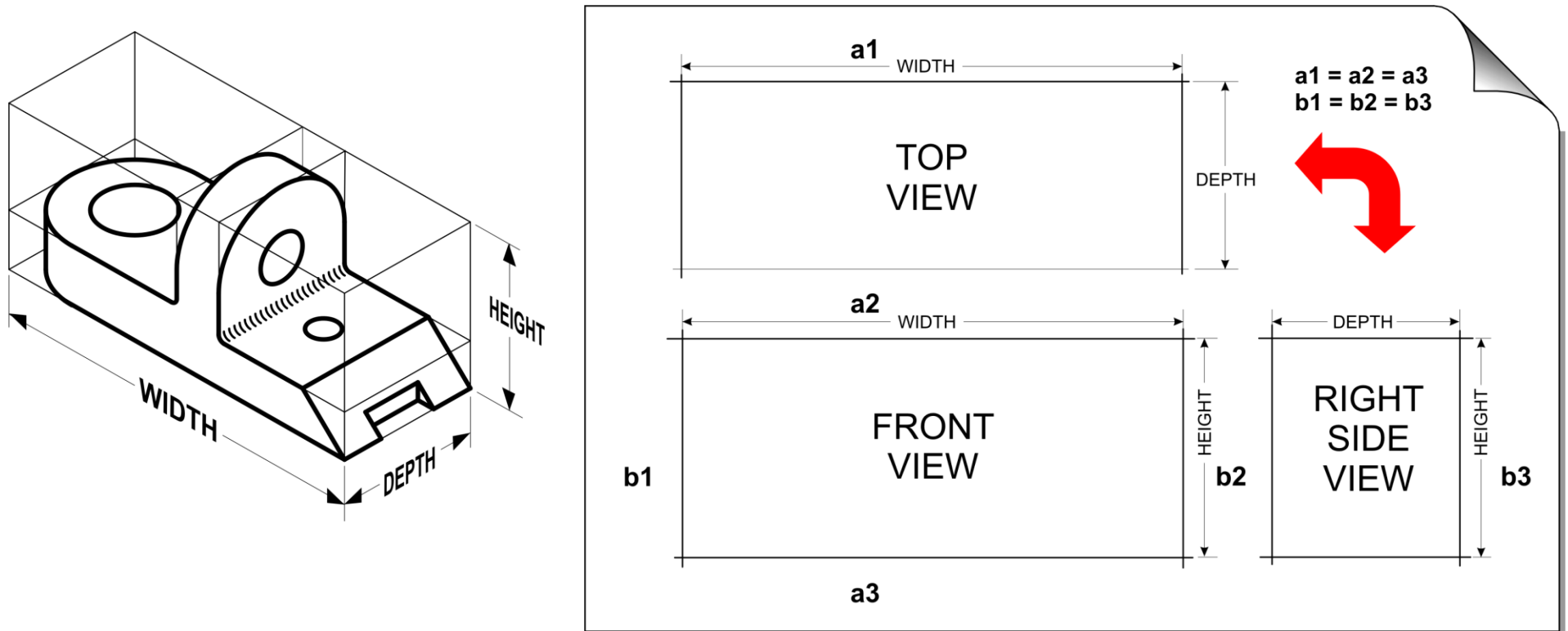


## Steps in Constructing a Multiview Drawing

The steps involved in constructing a multiview drawing with traditional tools are illustrated in **Figures 3.40-Figure 3.44**.

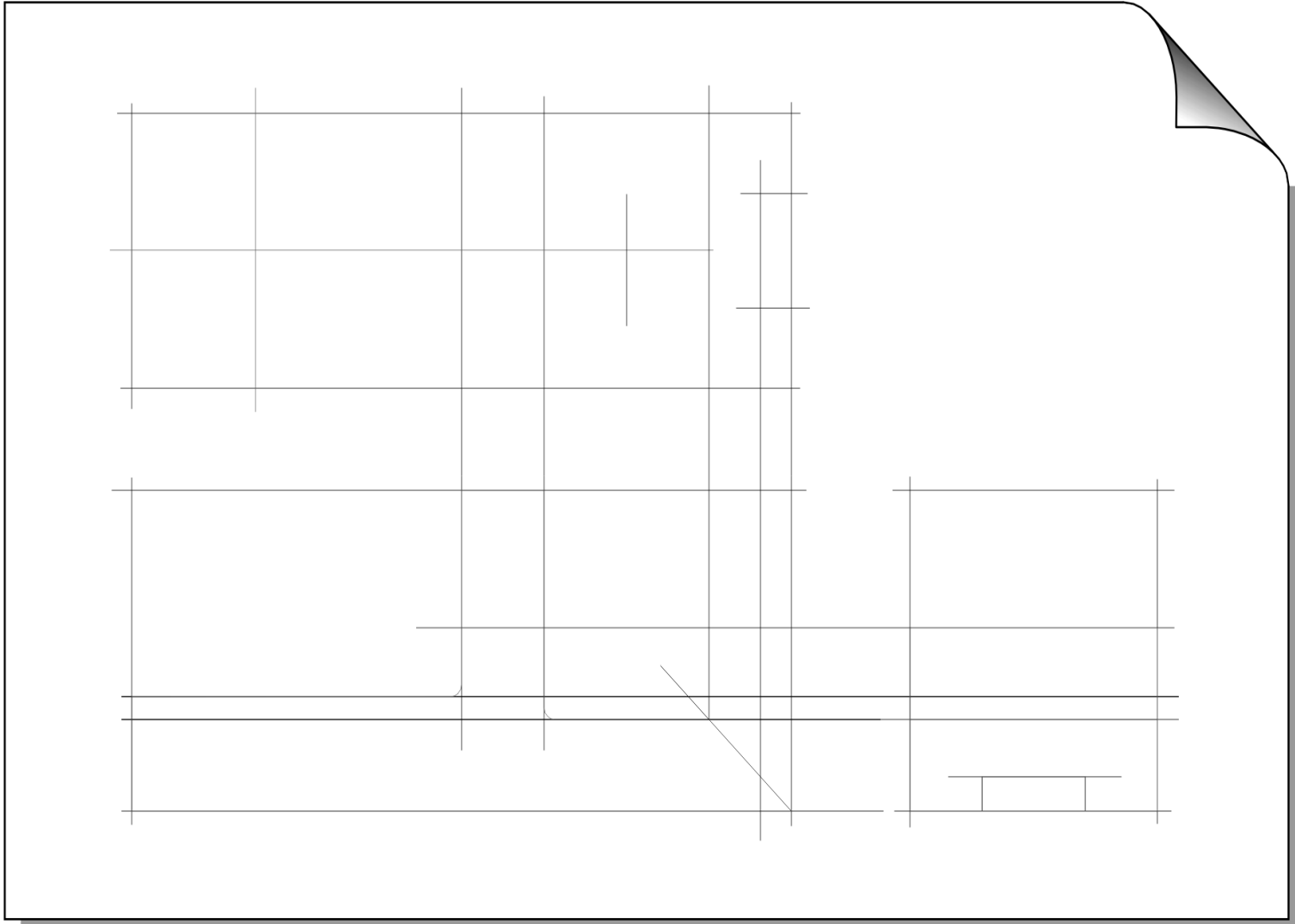
**Step 1.** Study the width, depth, and height of the object to be drawn and use these dimensions to determine the location of the views. Views are usually equally spaced both horizontally and vertically as shown in **Figure 3.40**. A formula for determine the horizontal spacing is to take the width of the sheet and subtract the width of the front view and the depth of the side view and divide the remainder by 3. To find the vertical spacing, take the height of the sheet and subtract the height of the front view and the depth of the top view and divide the remainder by 3.

**Figure 3.40** Determining View Spacing



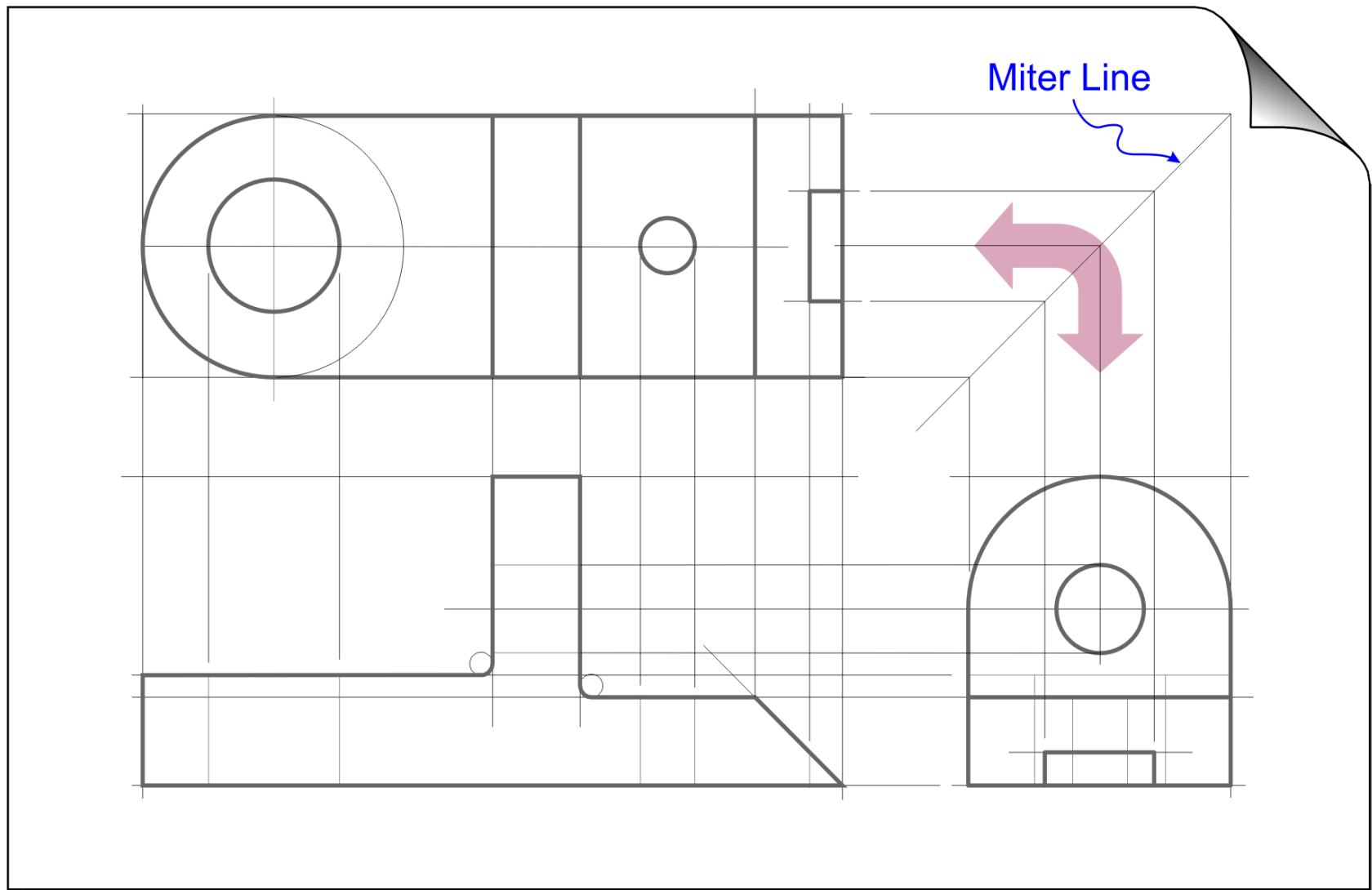
**Step 2.** The width, height and depth of the views is laid-out with light construction lines. See **Figure 3.41**.

**Figure 3.41** Rough Layout of Views.



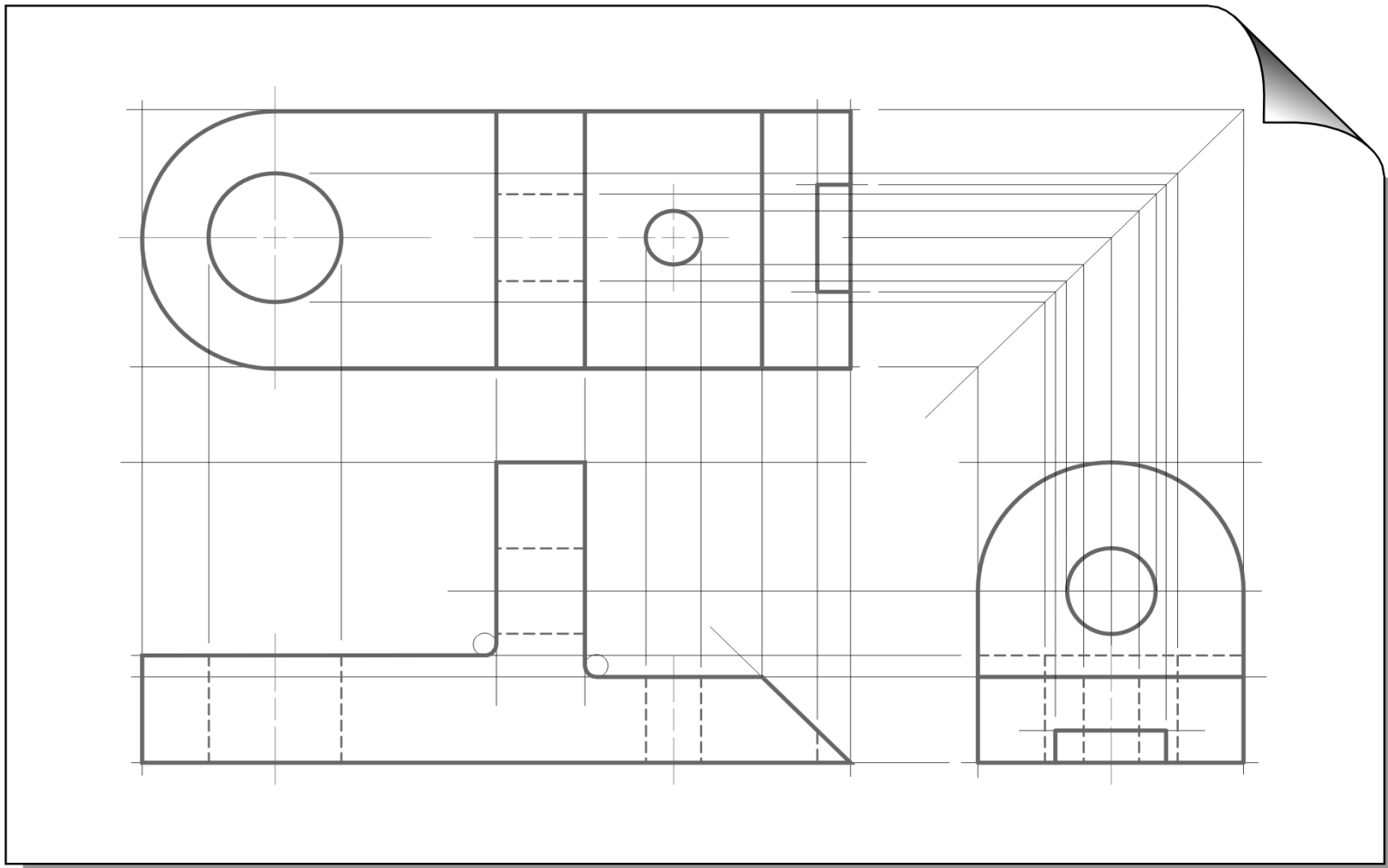
**Step 3.** A miter line is added so that orthographic projection techniques can be used to project between the top and side views. Circles and arcs are drawn in lightly with a circle template or compass. Information is projected between views with light construction lines. See **Figure 3.42**.

**Figure 3.42** Adding Miter Line and Circles.



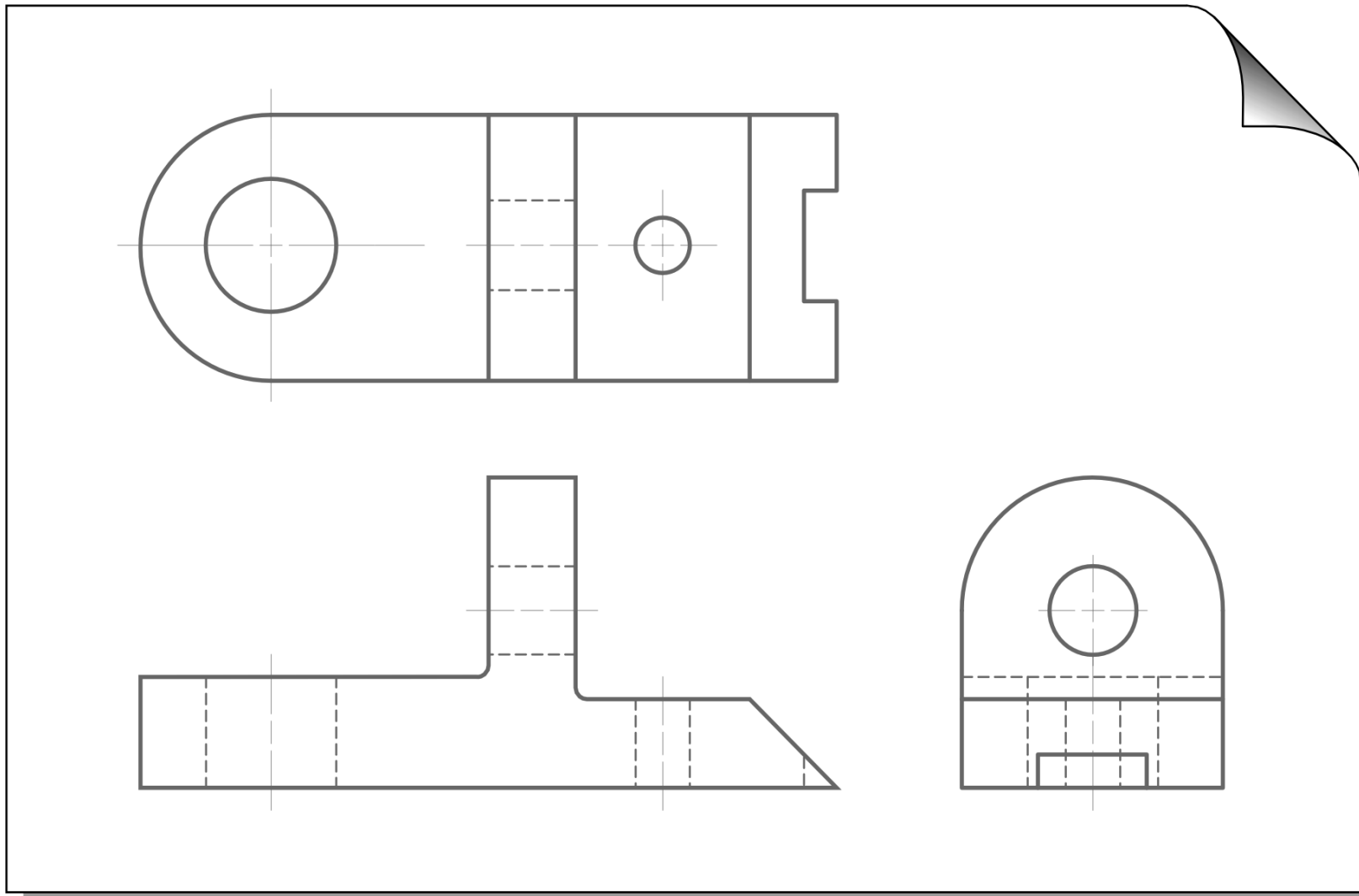
**Step 4.** Hidden and center lines are added as shown in **Figure 3.43**.

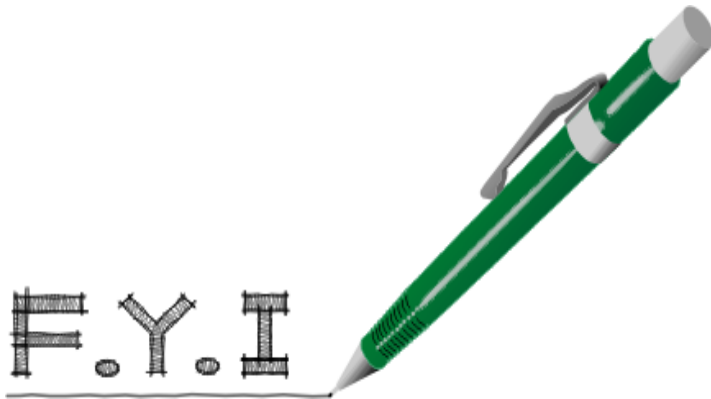
**Figure 3.43** Adding Hidden and Center Lines



**Step 5.** Construction lines are erased and the visible, hidden, and center lines are darkened to complete drawing. See **Figure 3.44**.

**Figure 3.44** Finished Drawing





It is best to draw all the views using construction lines.

If you make a mistake it is easier to erase a construction line than a dark visible, hidden, or center line.

Once you have drawn the views with construction lines, heavy up the Top view first, then the Front view, and the Side view last.

Darkening your lines in this order allows you to work away from your completed views and minimizes smudging.



## Summary

Although traditional drafting tools are rarely used in modern engineering and architectural offices, many of the same techniques developed by traditional drafters are still used in the creation of drawings with CAD.

For example, the location of points and planes is still projected between multiviews, only instead of using a drafting triangle, an AutoCAD drafter uses a drafting setting called **Ortho** to draw perfectly straight horizontal and vertical lines.

An understanding of how angles are measured with a protractor facilitates drawing angles with CAD.

Drafters and designers often use scales to take measurements off of plotted drawings (which is not always a good idea by the way) and an understanding of how to interpret an Engineer's, Architect's or Metric scale facilitates thinking about scaling in AutoCAD drawings.

The creation of free-hand sketches with legible lettering remains an important skill in today's design office.

Every professional drafter/designer, whether traditional or CAD, should develop a free-hand lettering style that is neat, uniform, and legible to facilitate communication between designers, or between designers and their clients.



# Technical Lettering Exercise 3-1

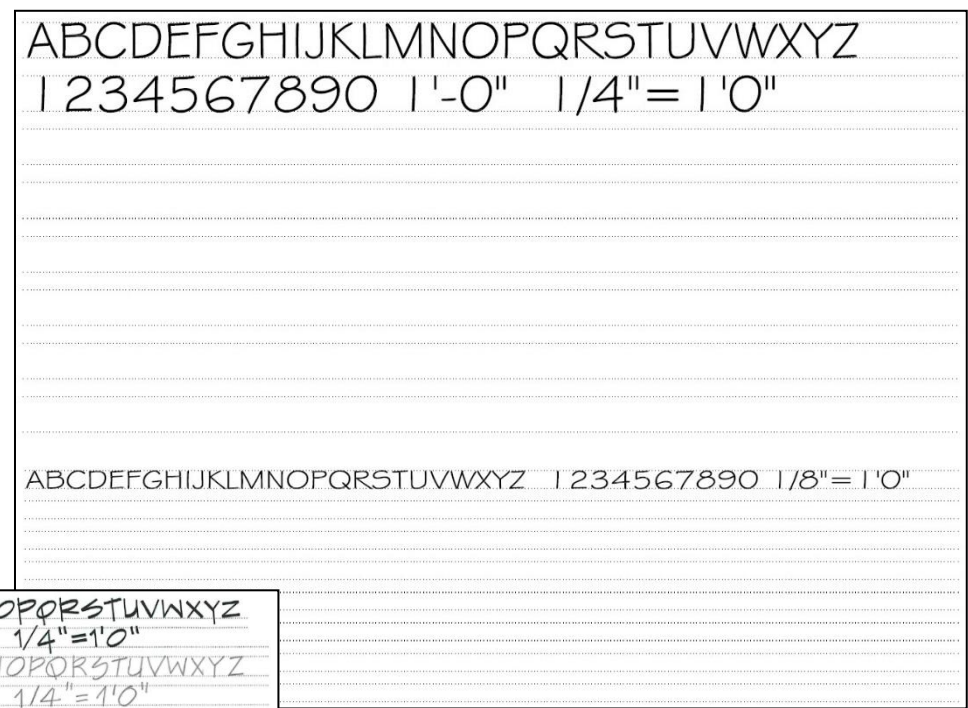
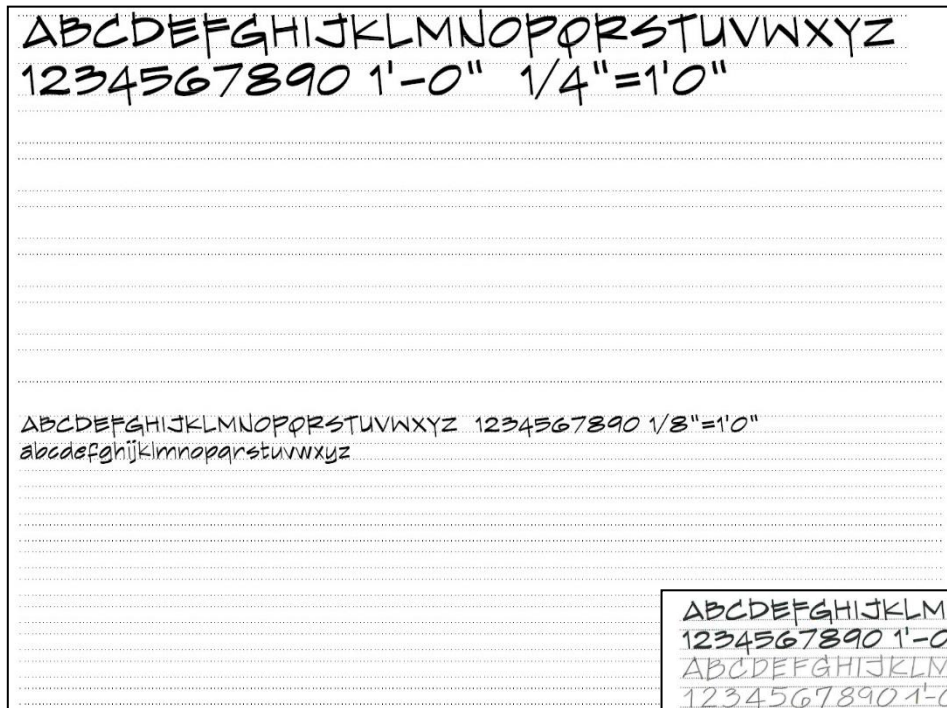
•Print the **Architectural Style Lettering Sheet.pdf** and the **Mechanical Style Lettering Sheet.pdf** located in the file downloads available for *Technical Drawing 101 with AutoCAD*. Practice lettering the alphabet and numerals in the guidelines as shown in Figures 3.46(a) and 3.46(b).

**FILE DOWNLOAD AVAILABLE FOR THIS PROJECT**

The **Architectural Style Lettering Sheet.pdf** and the **Mechanical Style Lettering Sheet.pdf** files used in *Exercise 3.1* are located inside the *Sketching and Lettering Plates* folder of the book's file downloads. These downloads are available by redeeming the access code that comes with this book. Please see the inside front cover of the book for further details.

**Figure 3.46(a)** Architectural Lettering Exercise

**Figure 3.46(b)** Mechanical Lettering Exercise

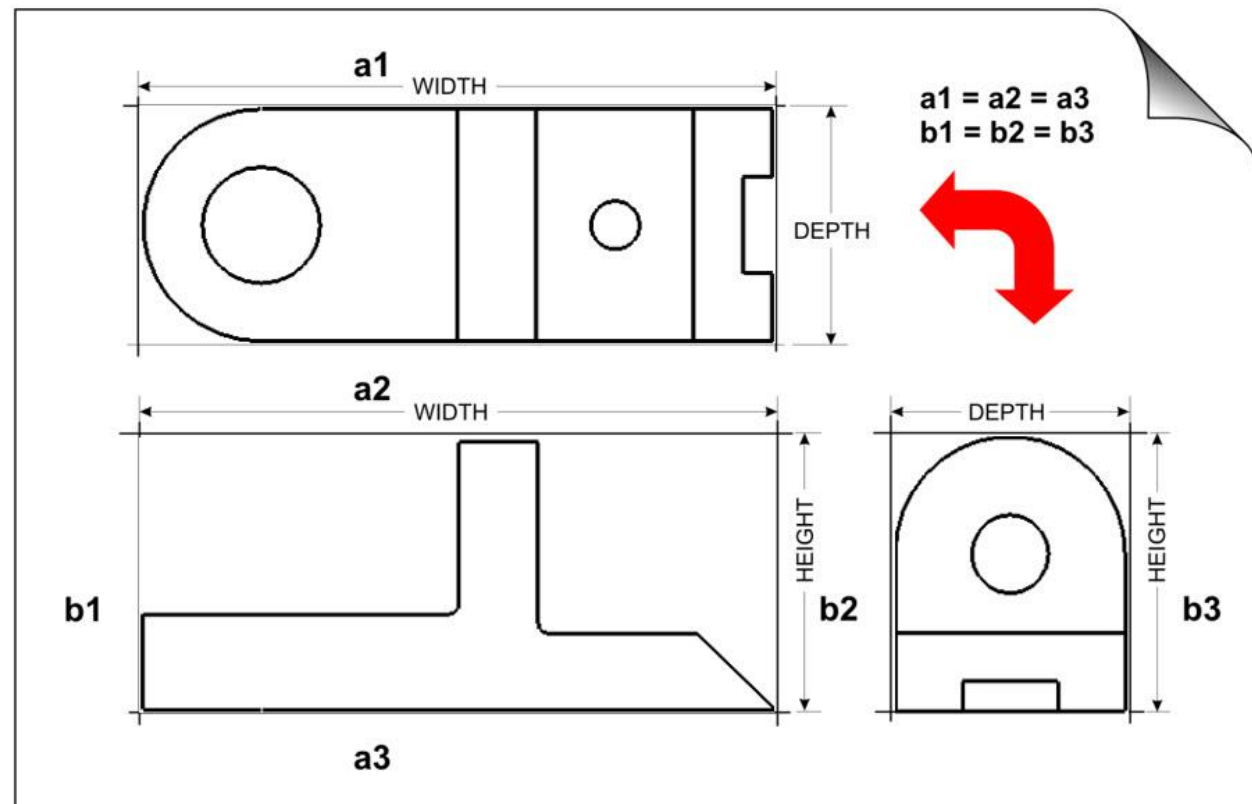
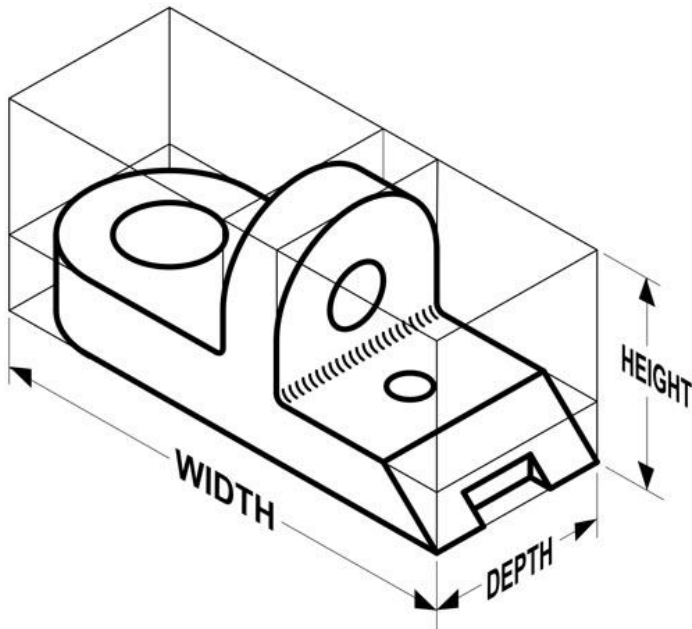




## Spacing a Multiview Drawing on a Sheet

The multiviews of an object are often equally spaced both horizontally and vertically on the sheet as shown in Figure 3.40. One method for determining the horizontal spacing between views is to take the overall width of the sheet and subtract the width of the front view and the depth of the side view and divide the remainder by 3. To find the vertical spacing between views, take the overall height of the sheet and subtract the height of the front view and the depth of the top view and divide the remainder by 3.

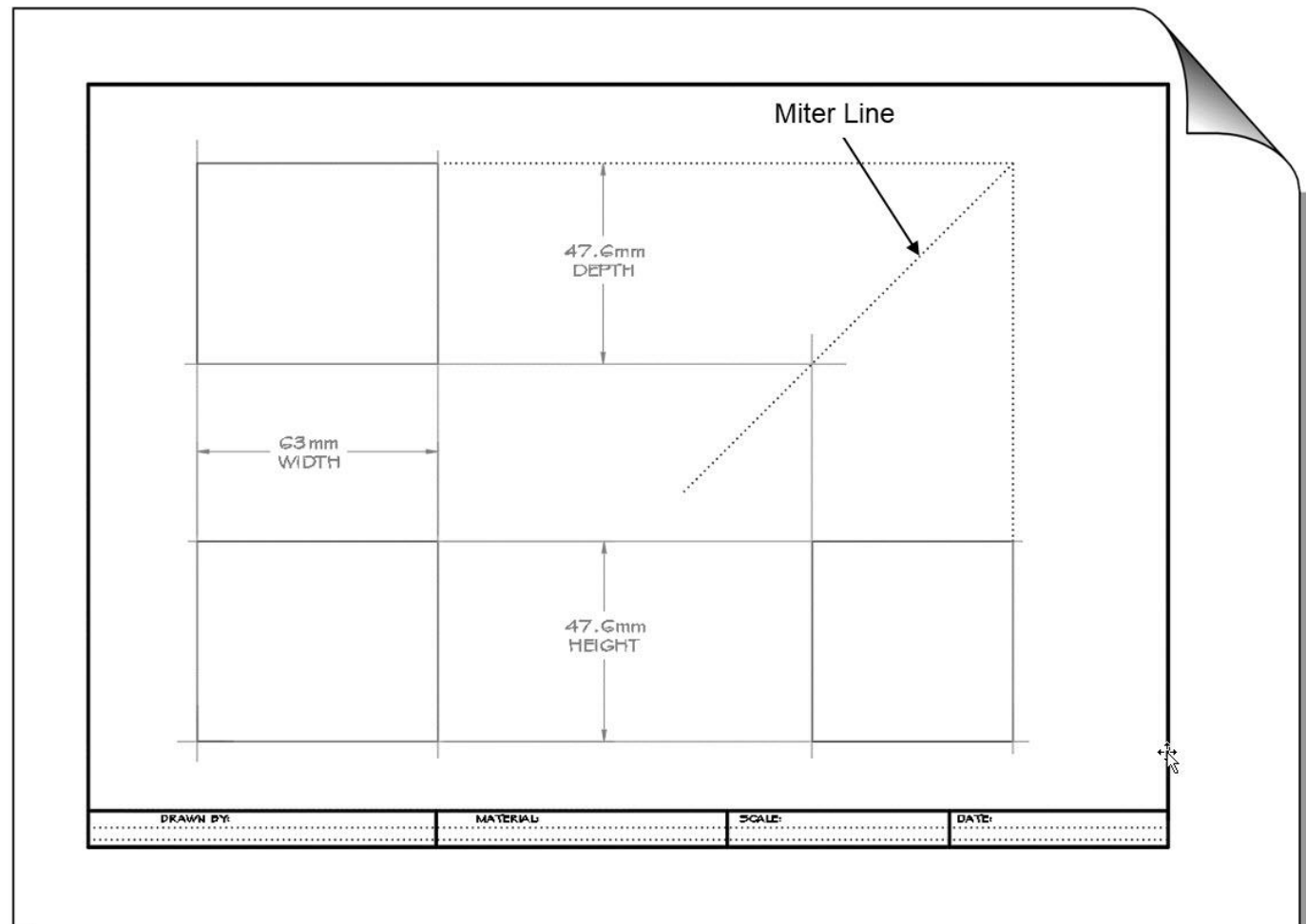
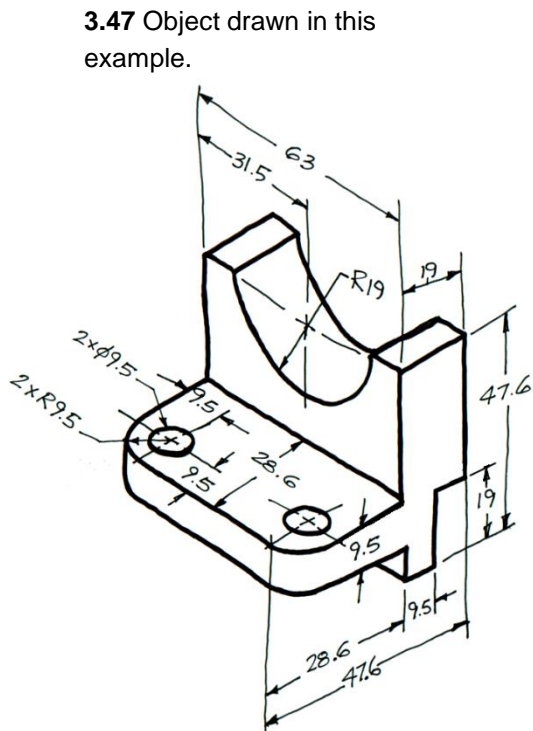
Figure 3.40 Determining View Spacing



## Steps In Constructing a Multiview Drawing

The steps below show how to construct the views for the object in the Traditional Drafting Project 3.1 presented later in this chapter. The views are drawn on the tear-out sheet located at the back of the textbook. Refer to **Figure 3.47** to see the dimensions and features for the object in the examples below.

**Step 1.** Study **Figure 3.47** and locate the dimensions for the width of the front view (63mm), height of the front view (47.6mm), and depth of the top view (47.6mm), and measuring with the Metric 1:100 scale, draw light construction lines to “box in” the front, top, and side views as shown in **Figure 3.41**. Use construction lines to project the width of the object’s front view to the top view. Using light lines, project the height of the front view to the side view and project the depth of the top view to the side view using the miter line.

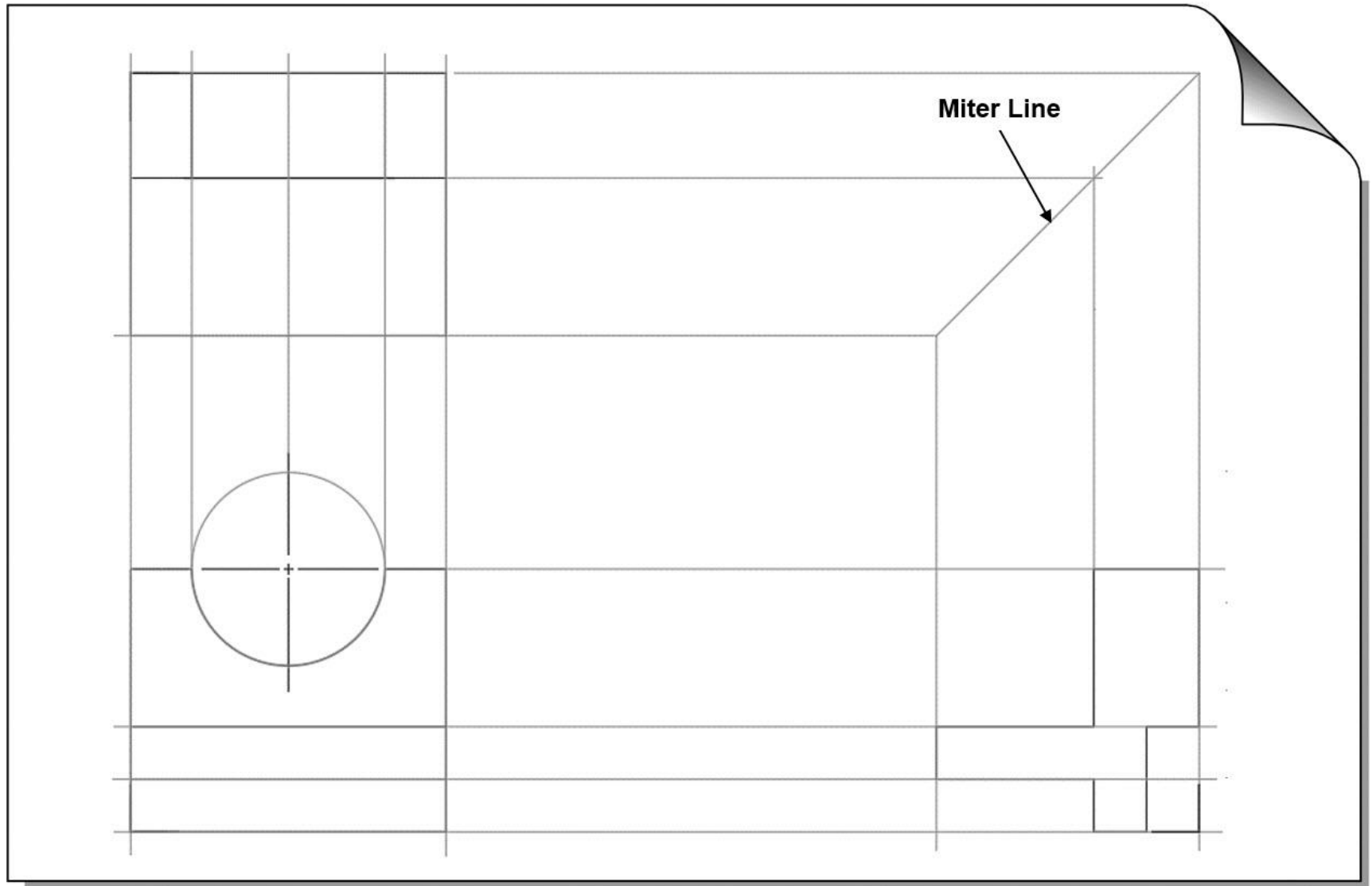


**Figure 3.41** Boxing in the Width, Height, and Depth of the Views (Using Dimensions Shown in **Figure 3.47**)



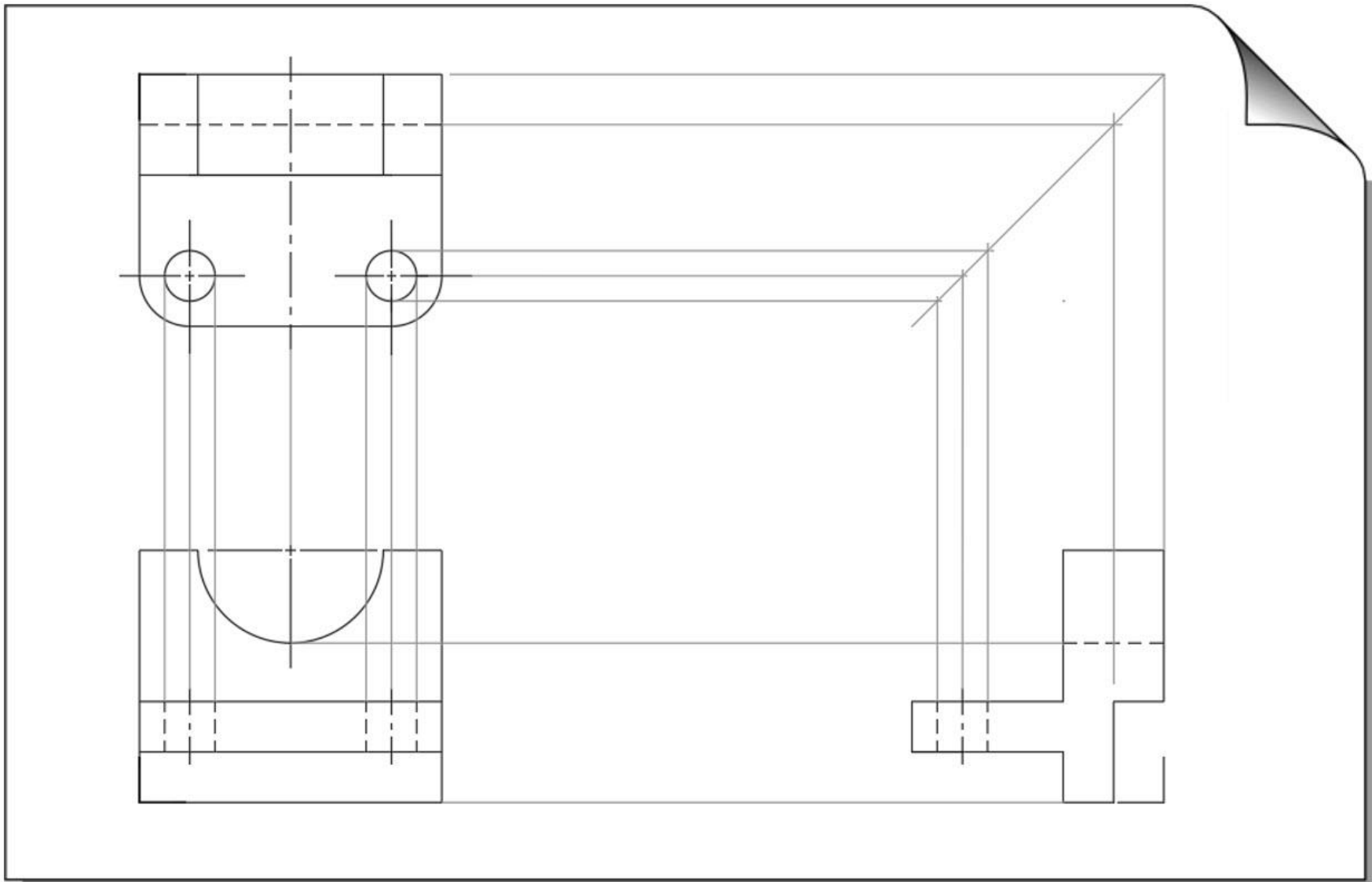
**Step 2.** Using light construction lines, continue to add basic features to the views as shown in **Figure 3.42**. The 38mm diameter circle (R19 x 2) in the front view is drawn in lightly using a circle template.

**Figure 3.42** Adding Features to the Views



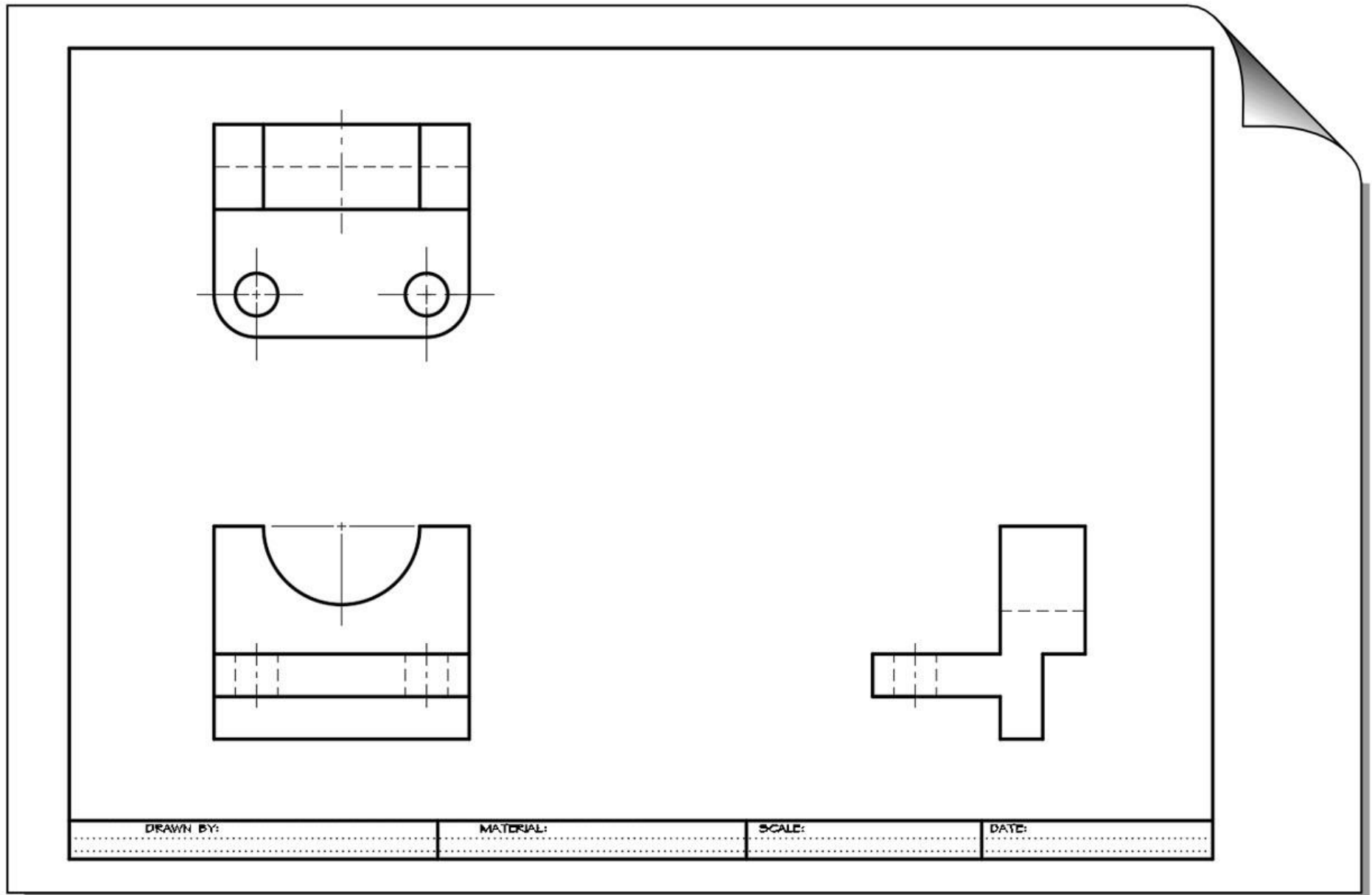
**Step 3.** Using light construction lines add other features as needed – such as the fillets (rounded corners) and holes to the top view. Project the hidden and center lines for holes and other features between the views using light lines as shown in **Figure 3.43**.

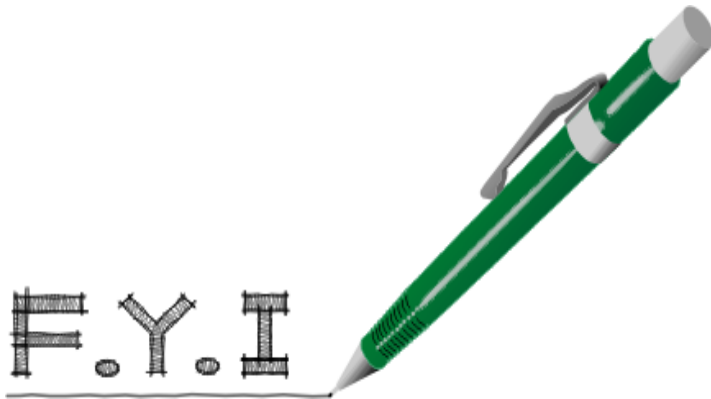
**Figure 3.43** Projecting Hidden and Center Lines of Holes



**Step 4.** Erase the construction lines and darken the visible, hidden, and center lines to complete the views as shown in **Figure 3.44**.

**Figure 3.44** The Views of the Object with Darkened Visible, Hidden, and Center Lines.





It is best to draw all the views using construction lines.

If you make a mistake it is easier to erase a construction line than a dark visible, hidden, or center line.

Once you have drawn the views with construction lines, heavy up the Top view first, then the Front view, and the Side view last.

Darkening your lines in this order allows you to work away from your completed views and minimizes smudging.



## Developing a Technical Lettering Style

Good lettering is a skill that is mastered only through practice. Over time, most drafters and designers develop their own unique lettering style. Some drafters, especially in the architectural field, develop an *artistic* lettering style (see Figure 3.45 top) while engineers often adopt a simpler lettering style (Fig 3.45 bottom). Although you may never develop a style that qualifies as “art,” with practice you can develop a style that is neat, legible, and uniform.

In the guidelines provided in **Figure 3.45**, practice lettering the alphabet and numerals. Try to match the lettering style shown in the example. Lettering should be dark, so press down hard with the pencil when making the strokes that form a letter or numeral.

**Figure 3.45** An Example of a Good Technical Lettering Style

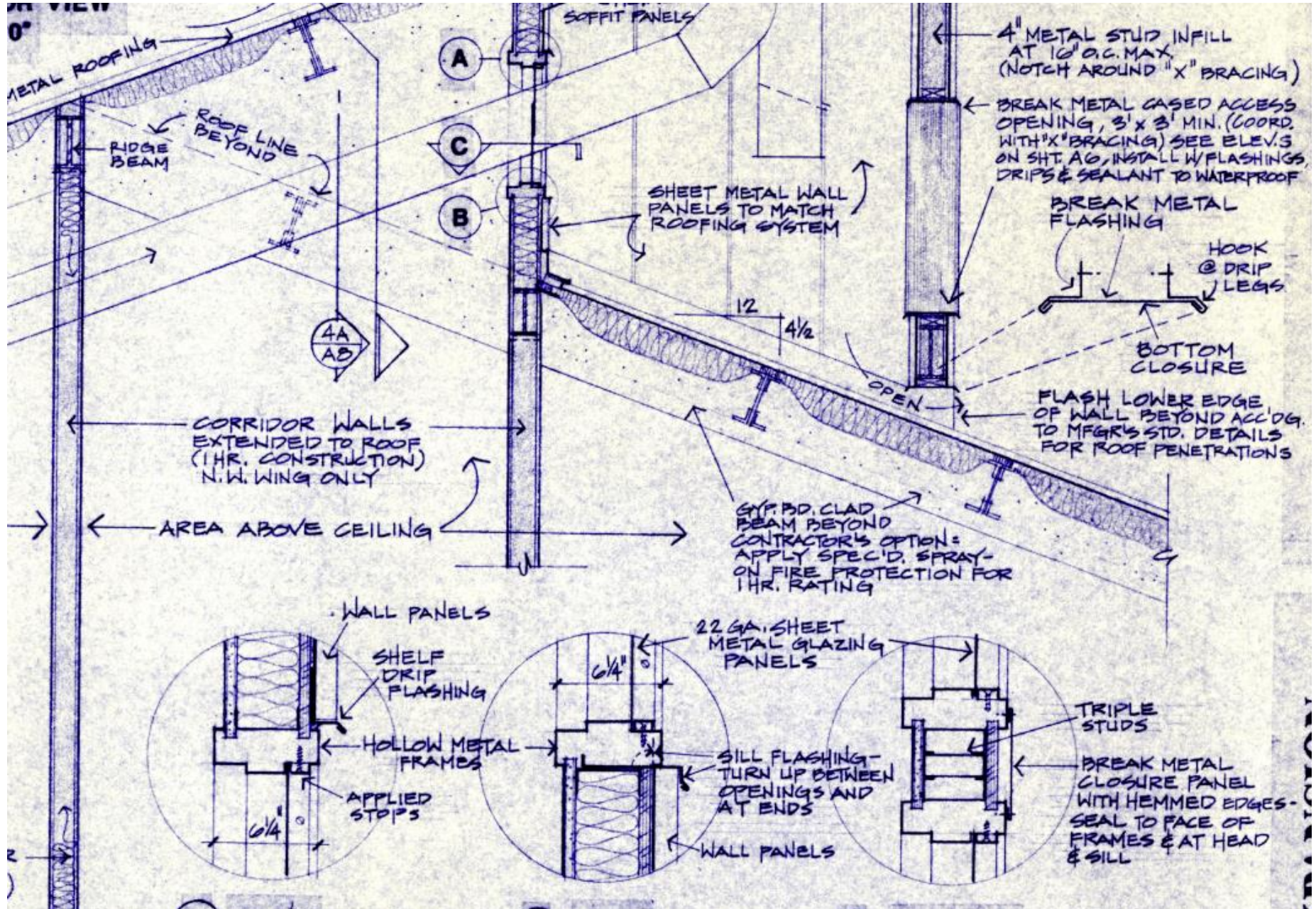
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z  
1 2 3 4 5 6 7 8 9 0 1'-0" 1/4"=1'0"

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z  
1 2 3 4 5 6 7 8 9 0 1'-0" 1/4"=1'0"



# WRITE LIKE A DESIGNER

The technical lettering in the architectural detail shown below is an excellent example of a lettering style that might be employed by a professional designer. Each letter is very legible and the shape, style, width, and height of the letters is consistent. All letters are capitalized.





# PRACTICE WRITING LIKE A DESIGNER

Technical drawings and sketches usually contain dimensions and notations. It is very important that any hand-lettered text on a drawing be neat, legible, and easily read on either an original drawing or a reproduction of the original. Most designers develop their own style of lettering over time. Practice lettering in the guidelines provided below. Try to approximate the style shown. This **Write Like a Design.pdf** is located inside the *Sketching and Lettering Plates* folder of the book's file downloads.

A	R	9	Q
B	S	A	R
C	T	B	S
D	U	C	T
E	V	D	U
F	W	E	V
G	X	F	W
H	Y	G	X
I	Z	H	Y
J	1	I	Z
K	2	J	1
L	3	K	2
M	4	L	3
N	5	M	4
O	6	N	5
P	7	O	6
Q	8	P	7

The "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG" is a pangram – a phrase containing all the letters of the alphabet. Practice lettering the phrase and numerals in the guide lines below.

THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG.

123456789



## Summary

Although traditional drafting tools are rarely used in modern engineering and architectural offices, many of the same techniques developed by traditional drafters are still used in the creation of drawings with CAD.

For example, the location of points and planes is still projected between multiviews, only instead of using a drafting triangle, an AutoCAD drafter uses a drafting setting called **Ortho** to draw perfectly straight horizontal and vertical lines.

An understanding of how angles are measured with a protractor facilitates drawing angles with CAD.

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The creation of free-hand sketches with legible lettering remains an important skill in today's design office.

Every professional drafter/designer, whether traditional or CAD, should develop a free-hand lettering style that is neat, uniform, and legible to facilitate communication between designers, or between designers and their clients.



# Technical Lettering Exercise 3-1 and 3-2

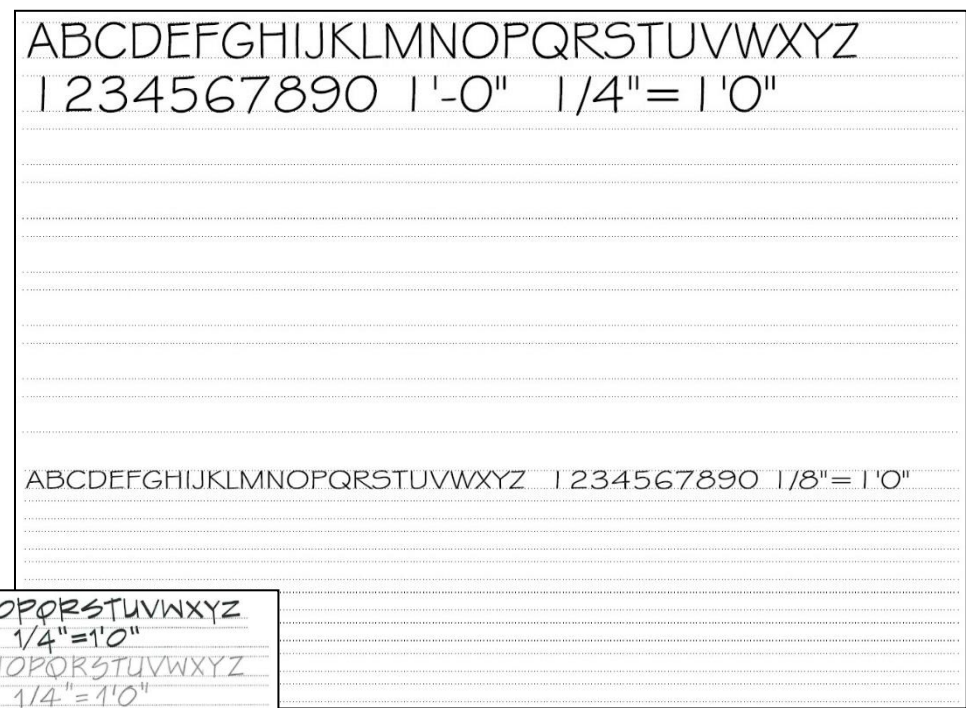
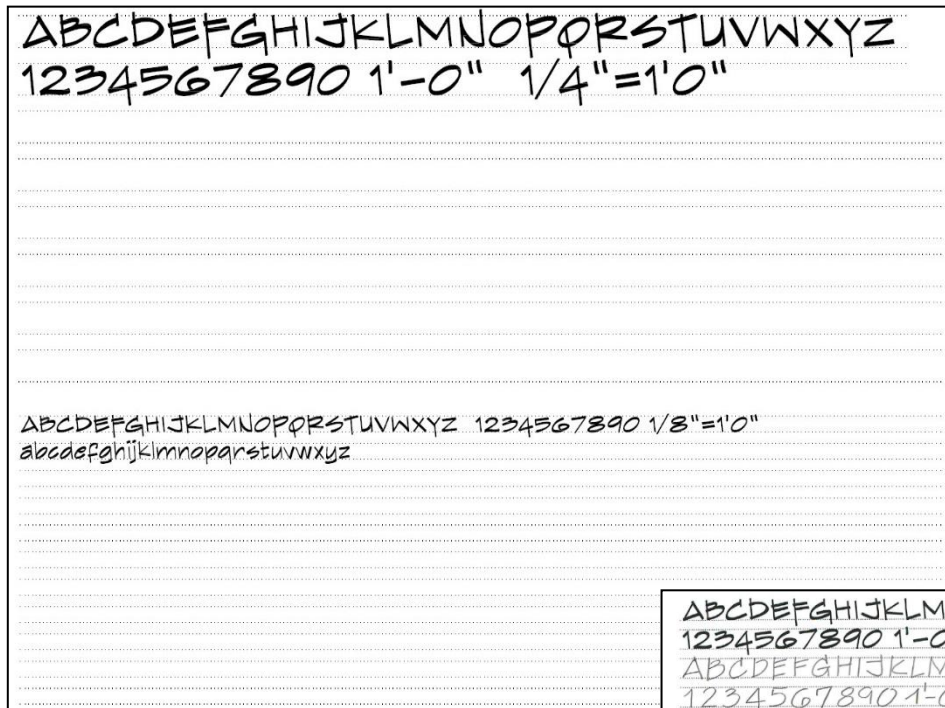
Print the **Architectural Style Lettering Sheet.pdf** and the **Mechanical Style Lettering Sheet.pdf** located in the file downloads available for *Technical Drawing 101 with AutoCAD*. Practice lettering the alphabet and numerals in the guidelines as shown in Figures 3.46(a) and 3.46(b). The **Write Like a Designer.pdf** shown on the next slide is also located inside the *Sketching and Lettering Plates* folder of the book's file downloads

## FILE DOWNLOADS AVAILABLE FOR THIS PROJECT

The **Architectural Style Lettering Sheet.pdf**, **Mechanical Style Lettering Sheet.pdf** and **Write Like a Designer.pdf** (shown on the next slide) referred to in *Exercise 3.1* are located inside the *Sketching and Lettering Plates* folder of the book's file downloads. These downloads are available by redeeming the access code that comes with this book. Please see the inside front cover of the book for further details.

Figure 3.46(a) Architectural Lettering Exercise

Figure 3.46(b) Mechanical Lettering Exercise



# WRITE LIKE A DESIGNER

Technical drawings and sketches usually contain dimensions and notations. It is very important that any hand-lettered text on a drawing be neat, legible, and easily read on either an original drawing or a reproduction of the original. Most designers develop their own style of lettering over time. Practice lettering in the guidelines provided below. Try to approximate the style shown. This **Write Like a Design.pdf** is located inside the *Sketching and Lettering Plates* folder of the book's file downloads.

A		R		9		Q	
B		S		A		R	
C		T		B		S	
D		U		C		T	
E		V		D		U	
F		W		E		V	
G		X		F		W	
H		Y		G		X	
I		Z		H		Y	
J		1		I		Z	
K		2		J		1	
L		3		K		2	
M		4		L		3	
N		5		M		4	
O		6		N		5	
P		7		O		6	
Q		8		P		7	

The "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG" is a pangram – a phrase containing all the letters of the alphabet. Practice lettering the phrase and numerals in the guide lines below.

THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG.

123456789



## Unit 3 Traditional Drafting Projects

### Project 3-1

### Traditional Drafting Project 1 (SI)

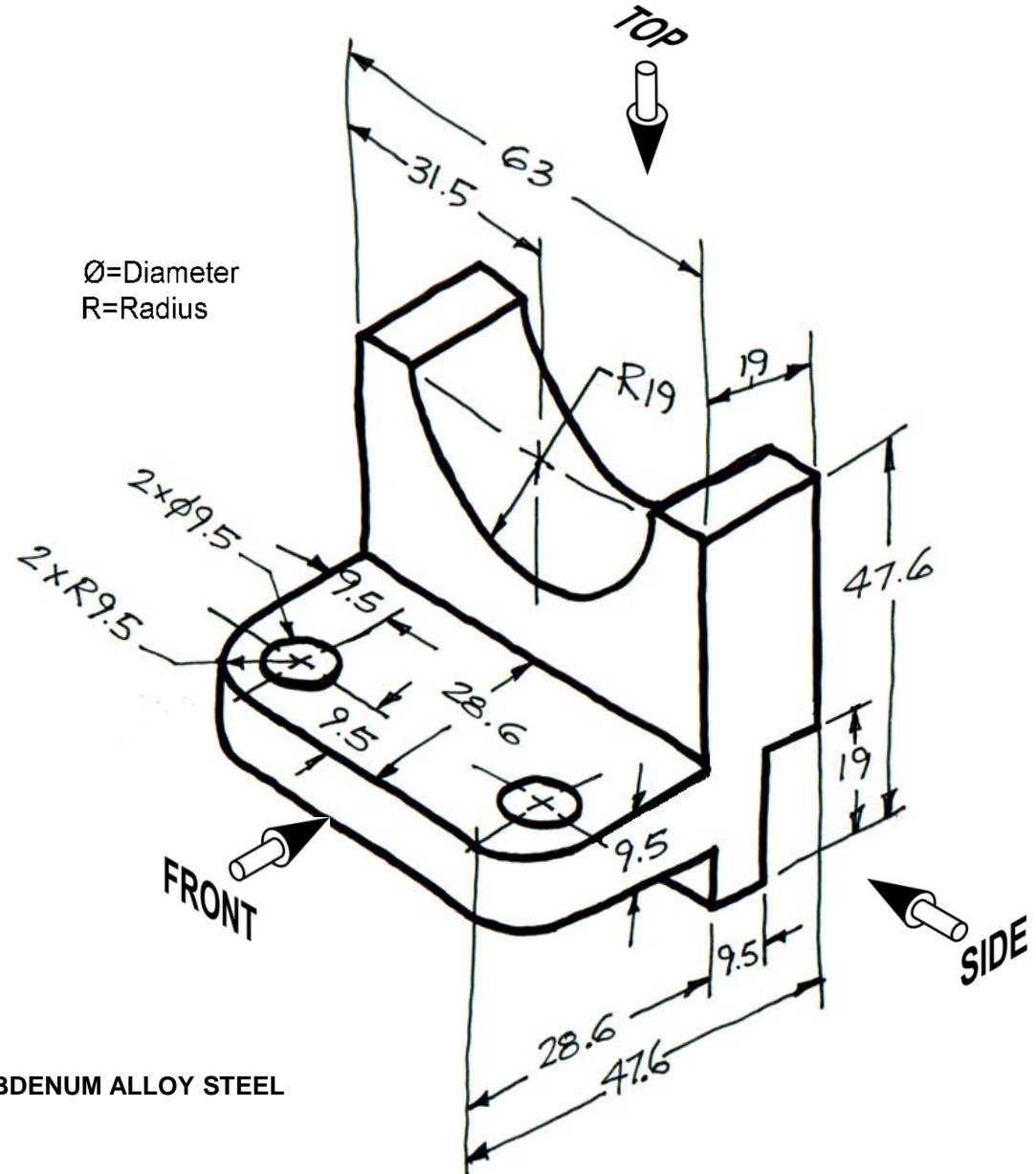
#### Directions

Carefully remove the sheet for Traditional Drafting Project 1 (see Figure 3.48) located at the back of this book and draw the front, top, and right views of the object in **Figure 3.47**. Refer to the steps shown in **Figures 3.41** through **3.44** to construct the views.

This drawing employs international units (SI), so use the Metric scale marked 1:100 (refer to Figure 3.18) to draw the object full size (1 = 1).

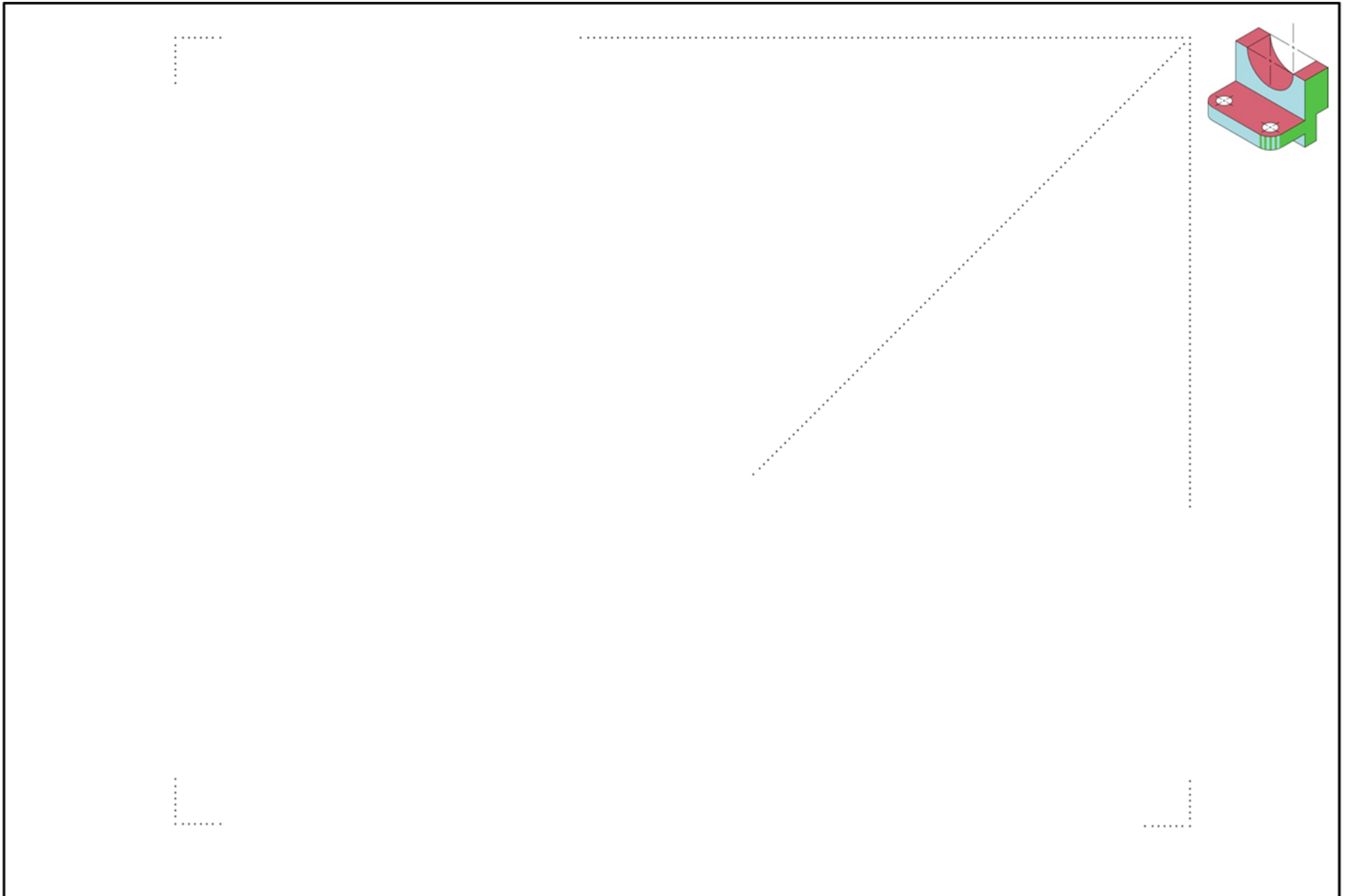
Add dimensions to the views as instructed by your teacher. Letter your name, the material of the part, today's date, and the drawing scale in the guidelines provided (refer to Figure 3.48).

Figure 3.47 Traditional Drafting Project 1



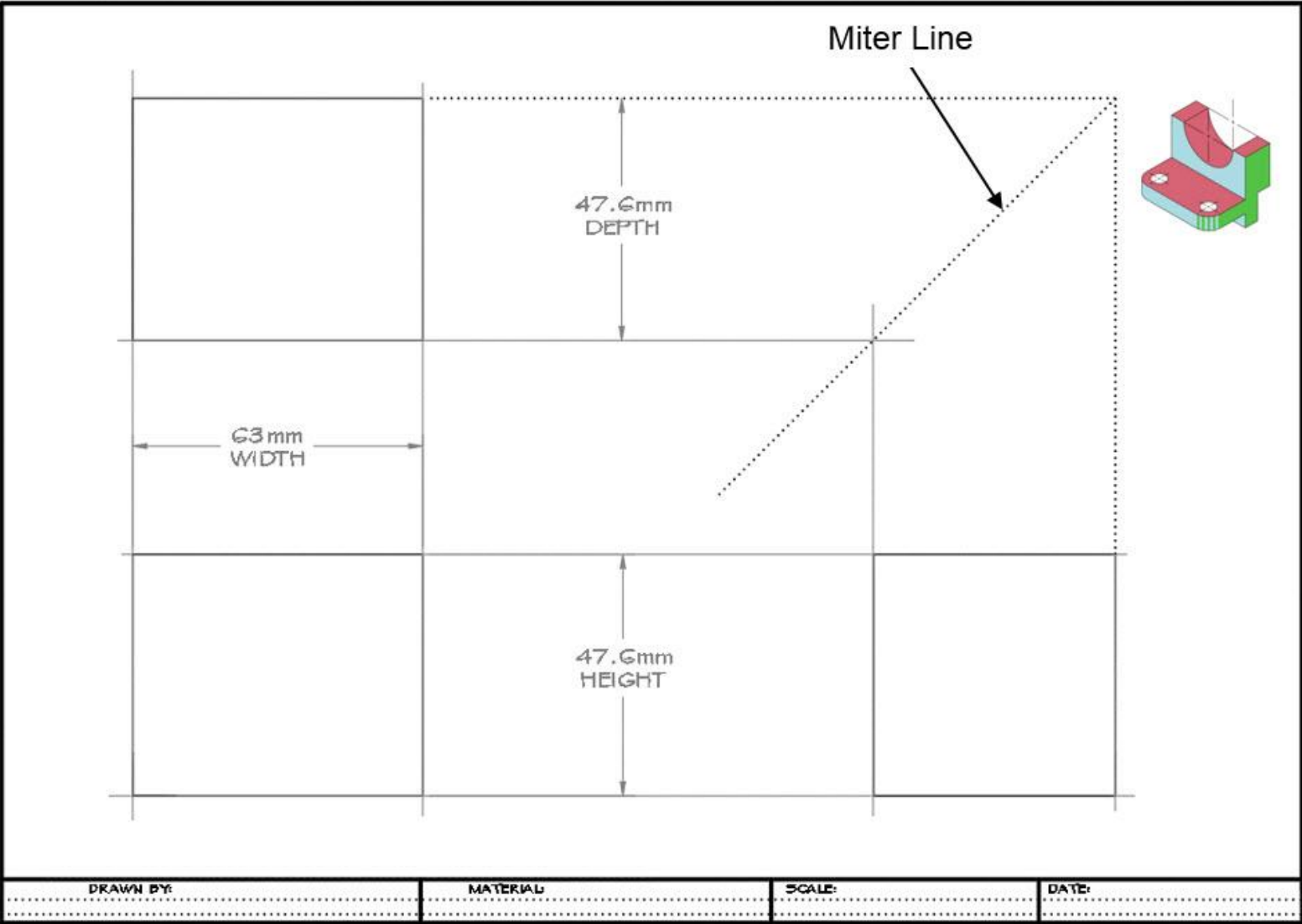
MATERIAL: MOLYBDENUM ALLOY STEEL



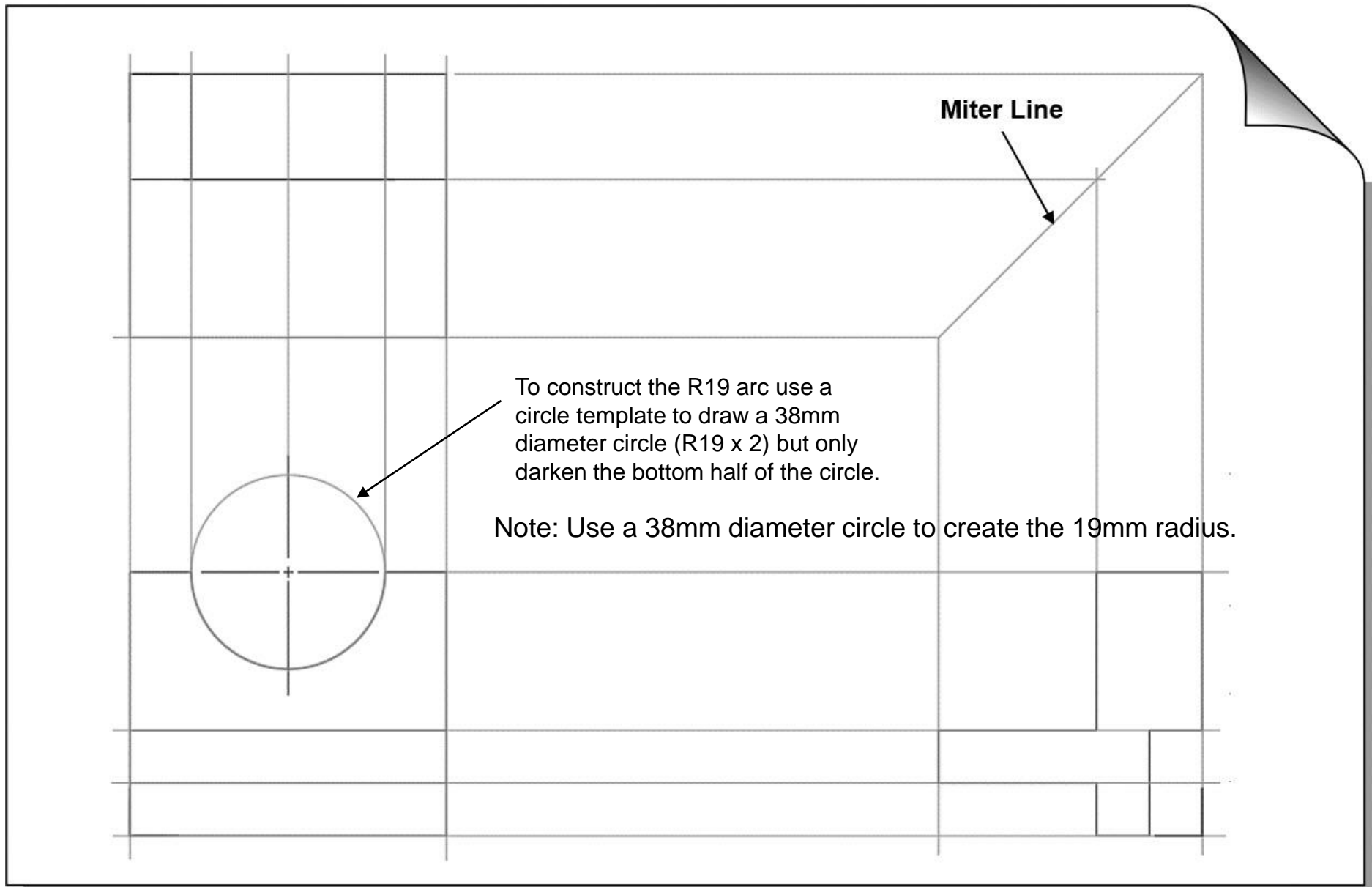
			



Step 1. Lightly "box in" the Width, Height, and Depth of the views using dimensions shown in **Figure 3.47**.

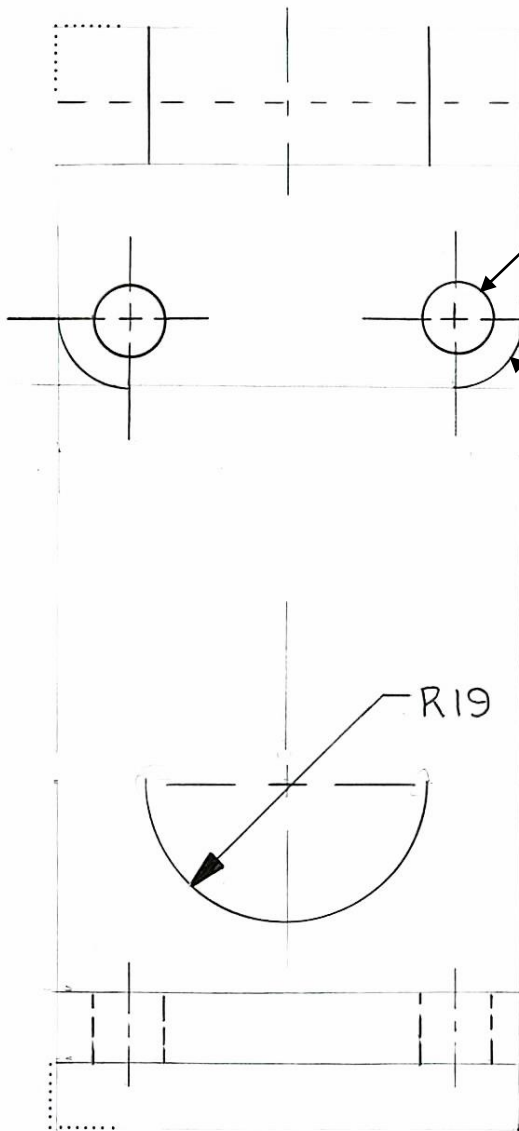
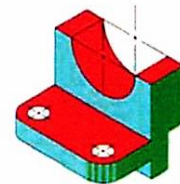


Step 2. Add features to the views. Apply orthographic projection techniques where possible.





Step 3. Add holes and radii to top view with a circle template.



Use a circle template to draw a 9.5mm diameter circle. Center the circle 9.5mm from the right edge and 9.5mm from the front edge of the object.

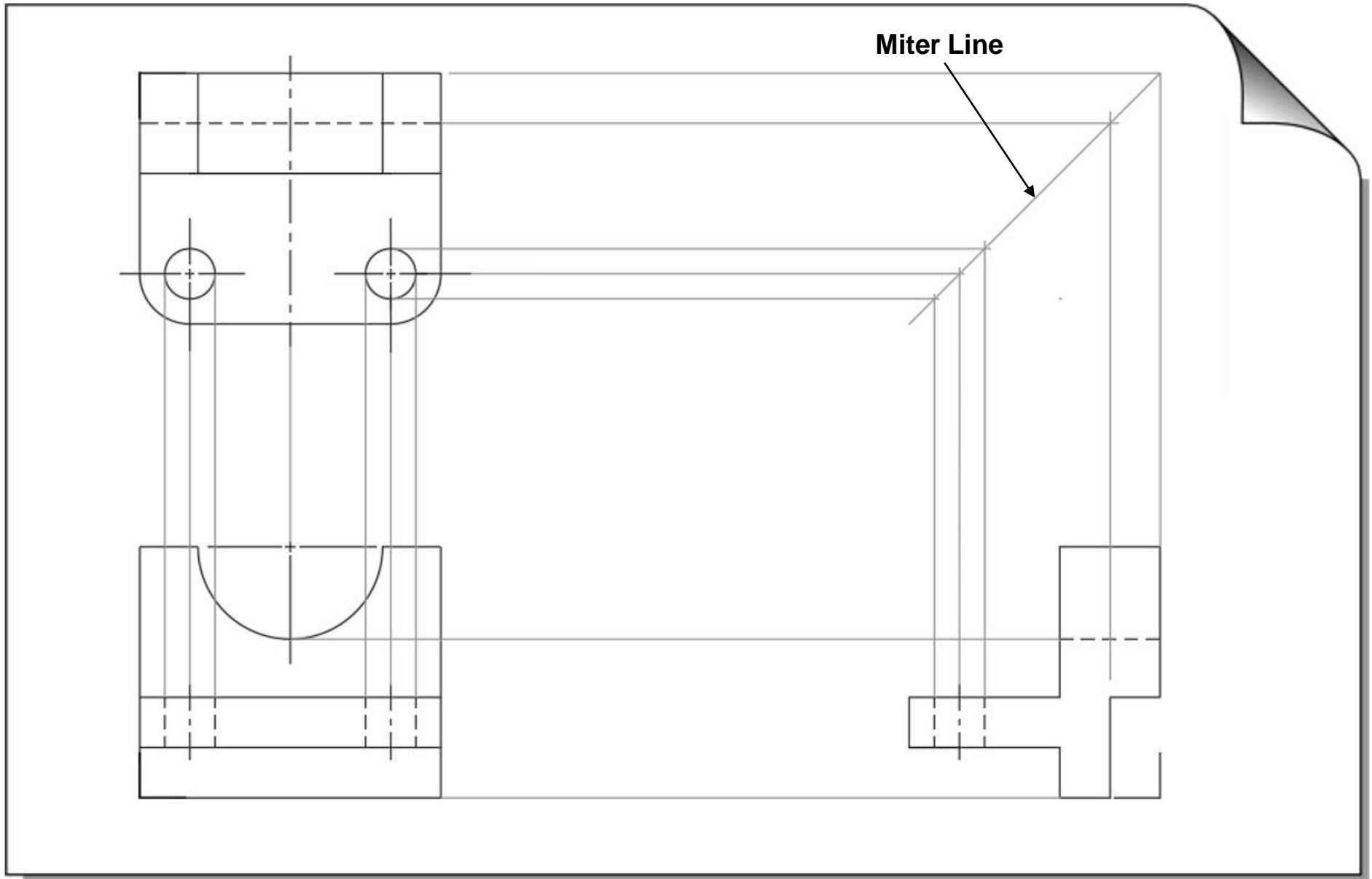
Note: The 9.5mm circles and 9.5mm radii are concentric.

To construct the R9.5 arc use a circle template to draw a 19mm diameter circle (R9.5 x 2) but only darken the bottom-right quadrant of the circle. Center the circle 9.5mm from the right edge and 9.5mm from the front edge of the object.

DRAWN BY:	MATERIAL:	SCALE:	DATE:
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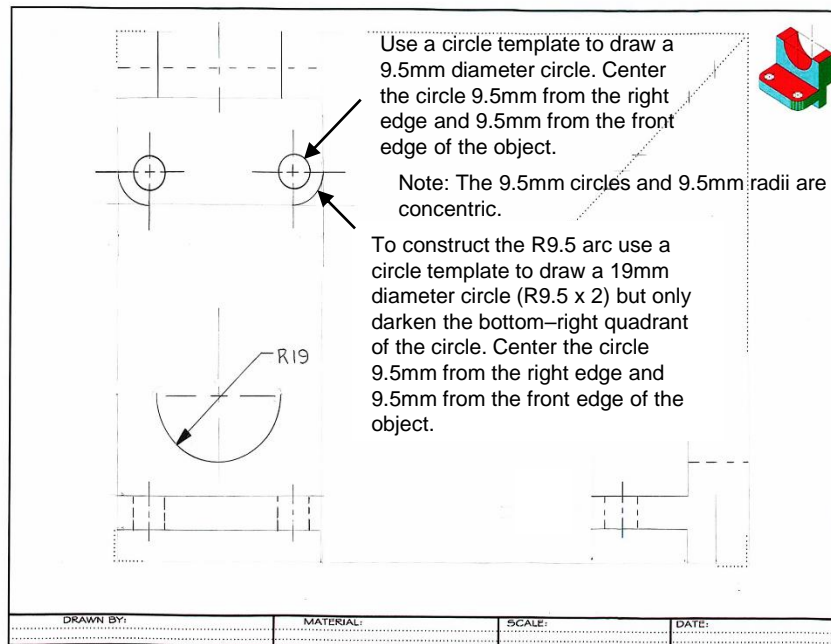
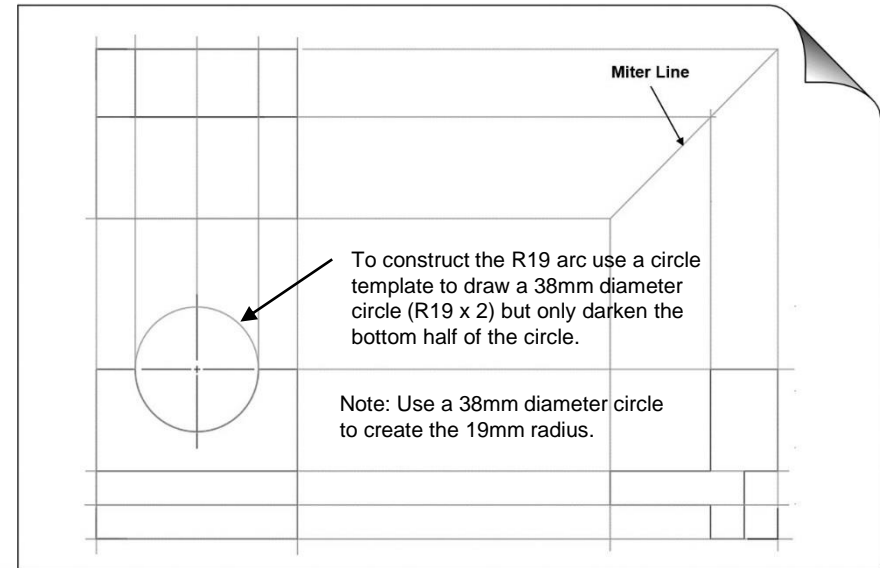
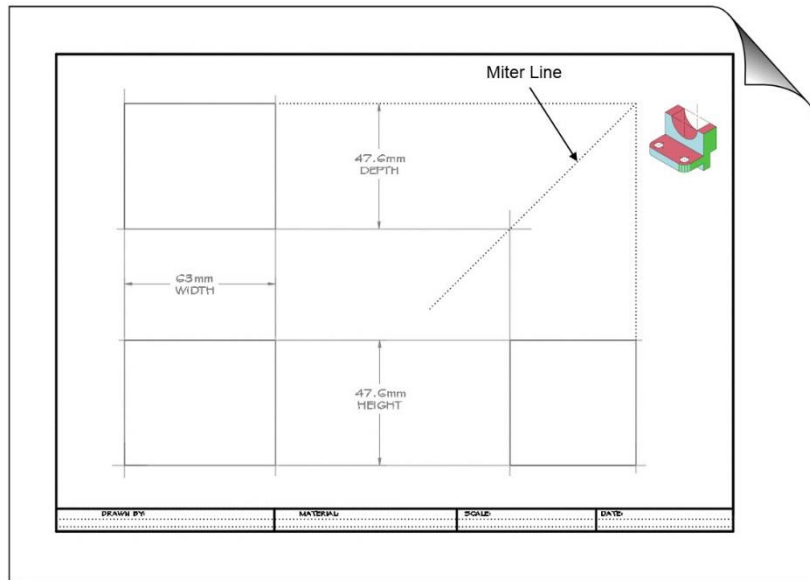
Step 4. Project hidden and center lines between views.



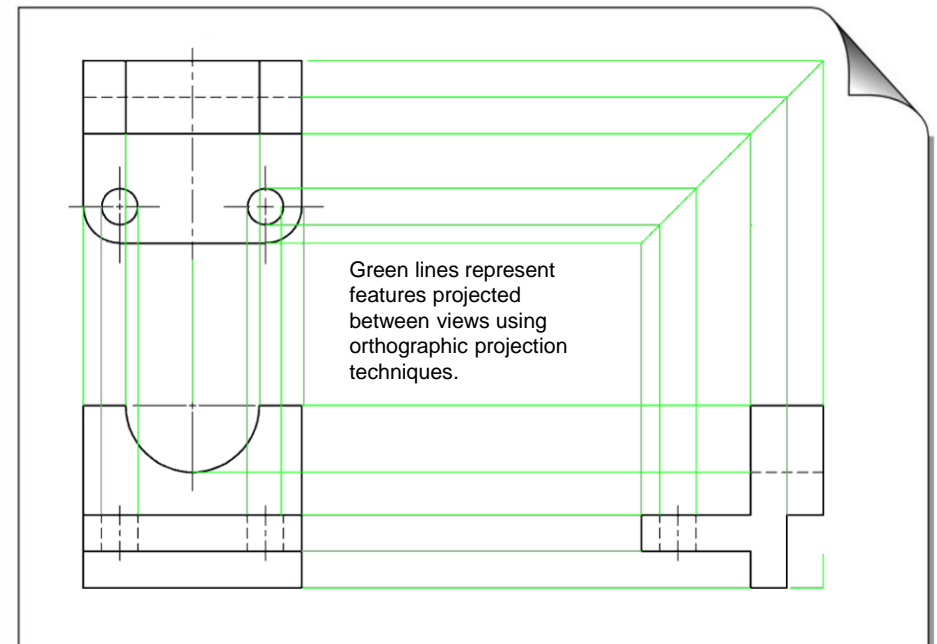
# Project 3-1 Traditional Drafting Project 1 (SI) – Help Sheet

Step 1. Lightly “box in” the Width, Height, and Depth of the views using dimensions shown in **Figure 3.47**.

Step 2. Add features to the views. Apply orthographic projection techniques where possible.



Step 3. Add holes and radii to top view using a circle template.



Step 4. Project hidden and center lines between views using orthographic projection techniques.



Step 5. Add dimensions to views – draw guidelines for text..

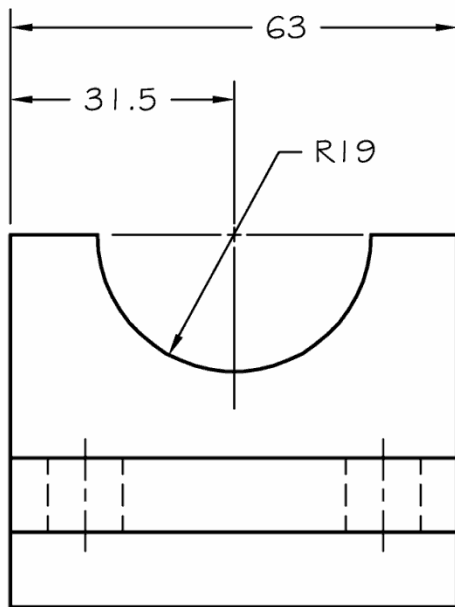
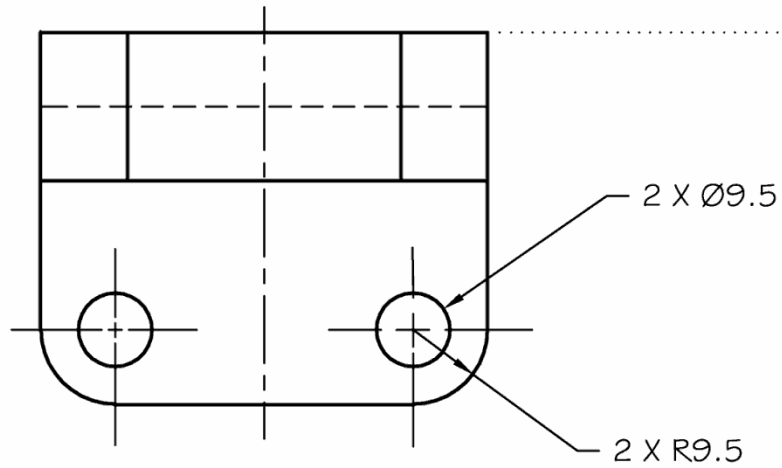
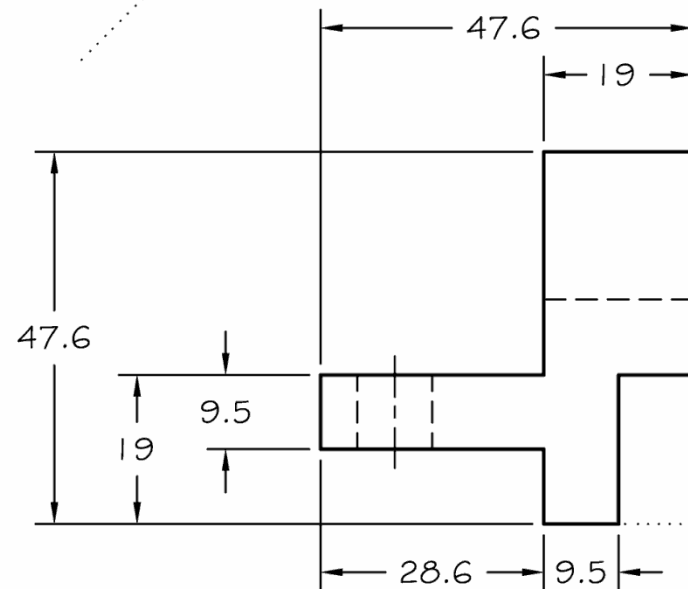
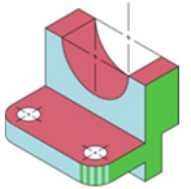


Figure 3.48 Finished Project



DRAWN BY:  
PRINT YOUR NAME HERE

MATERIAL:  
MOLY ALLOY STEEL

SCALE:  
1 = 1

DATE:  
06-07-20XX



# Project 3-2

## Traditional Drafting Project 2

Figure 3.49 Traditional Drafting Project 2

### Directions

Carefully remove the sheet for *Traditional Drafting Project 2* located at the back of this book. Using the Engineer's 10 scale (refer to Figure 3.16), draw the front, top, and right views of the object in Figure 3.49.

The views will be drawn full scale (1=1). Add dimensions to the views as instructed by your teacher. Letter your name, the material of the part, today's date, and the drawing scale in the guidelines provided (refer to Figure 3.49).

Ø=Diameter

R=Radius

THRU=Hole passes all the way through the part

(1.25)=Reference Dimension

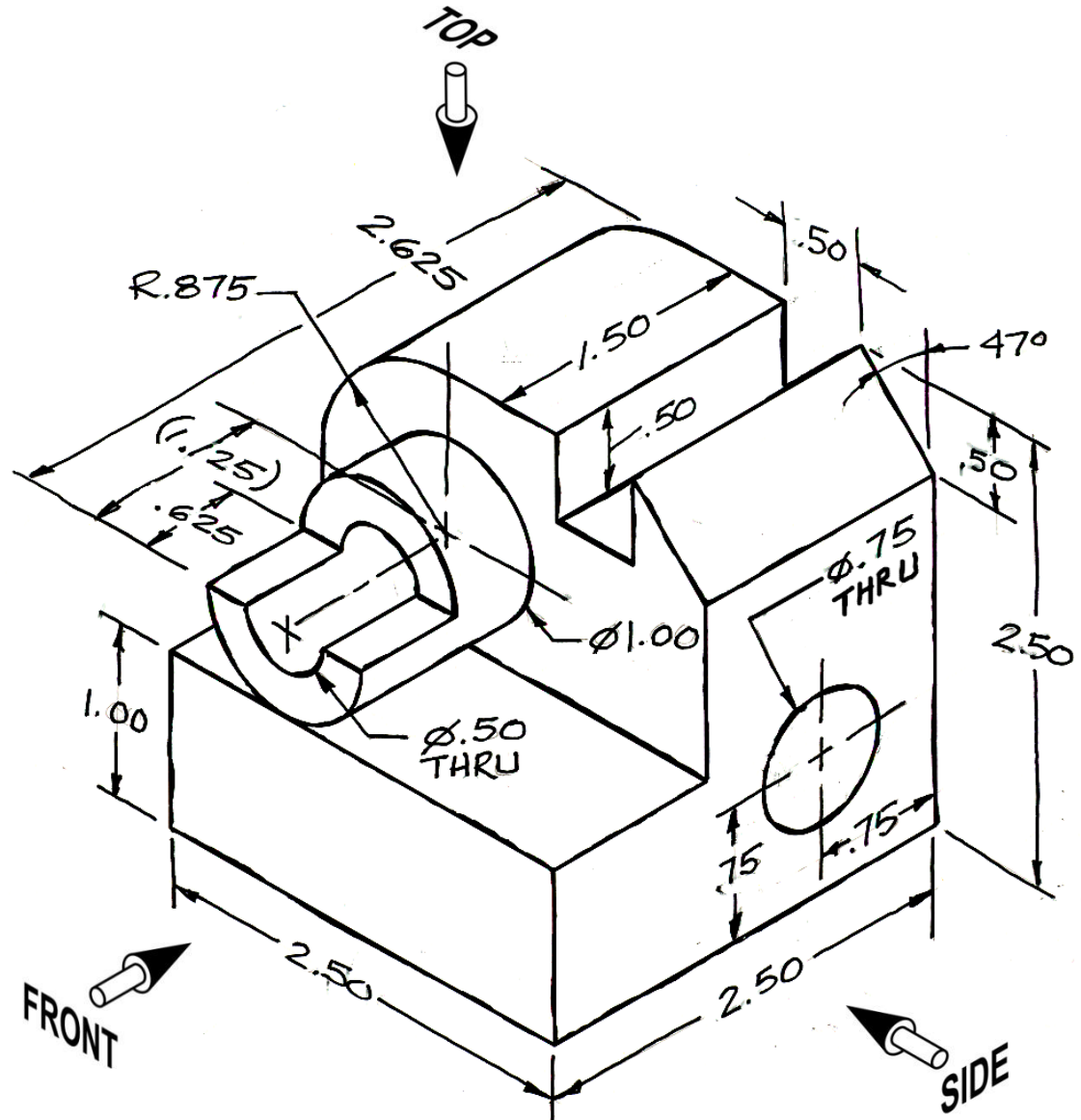
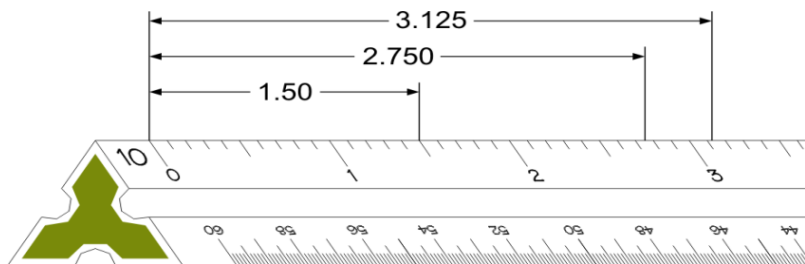
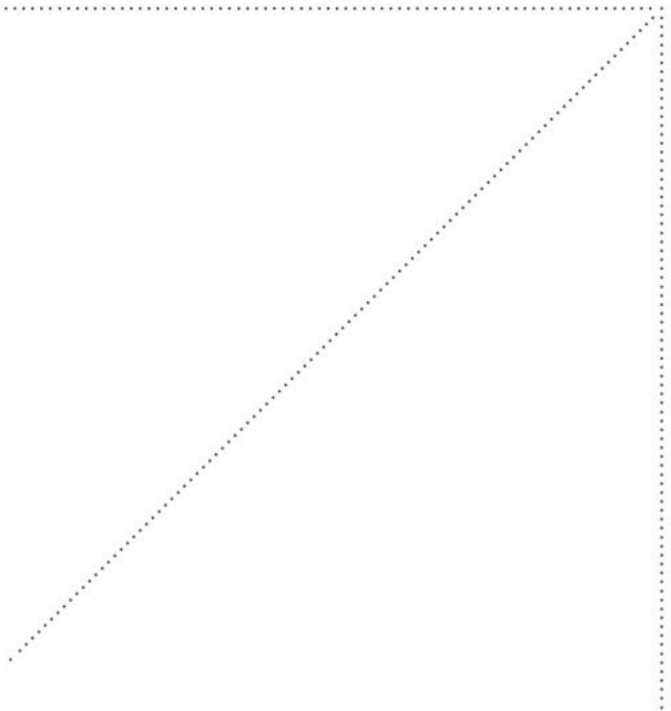
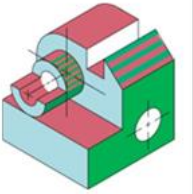


Figure 3.16 Measuring Decimal Inches with the Engineer's 10 Scale





DRAWN BY:  
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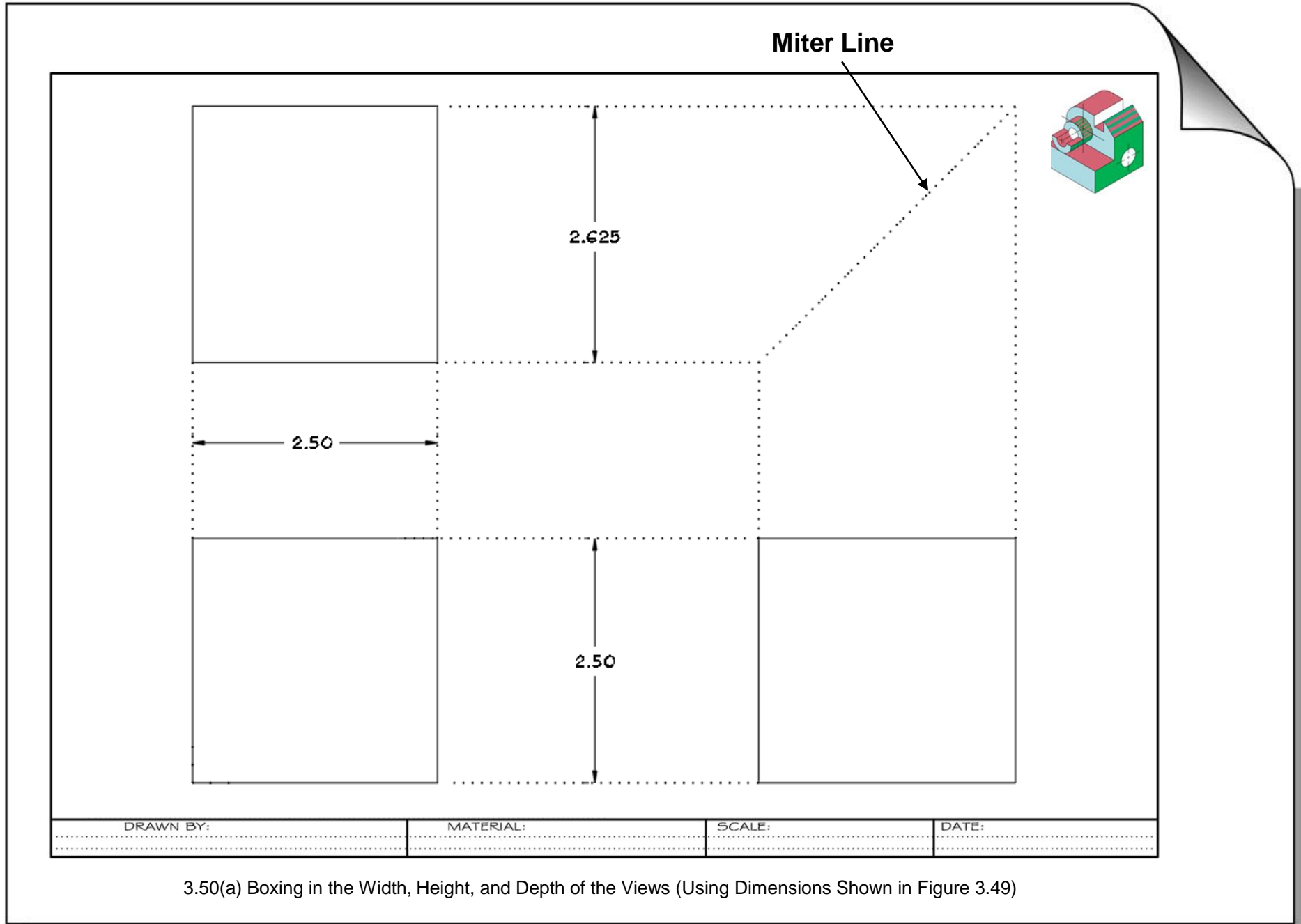
SCALE:  
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# Project 3-2 Traditional Drafting Project 2 – Help Sheet

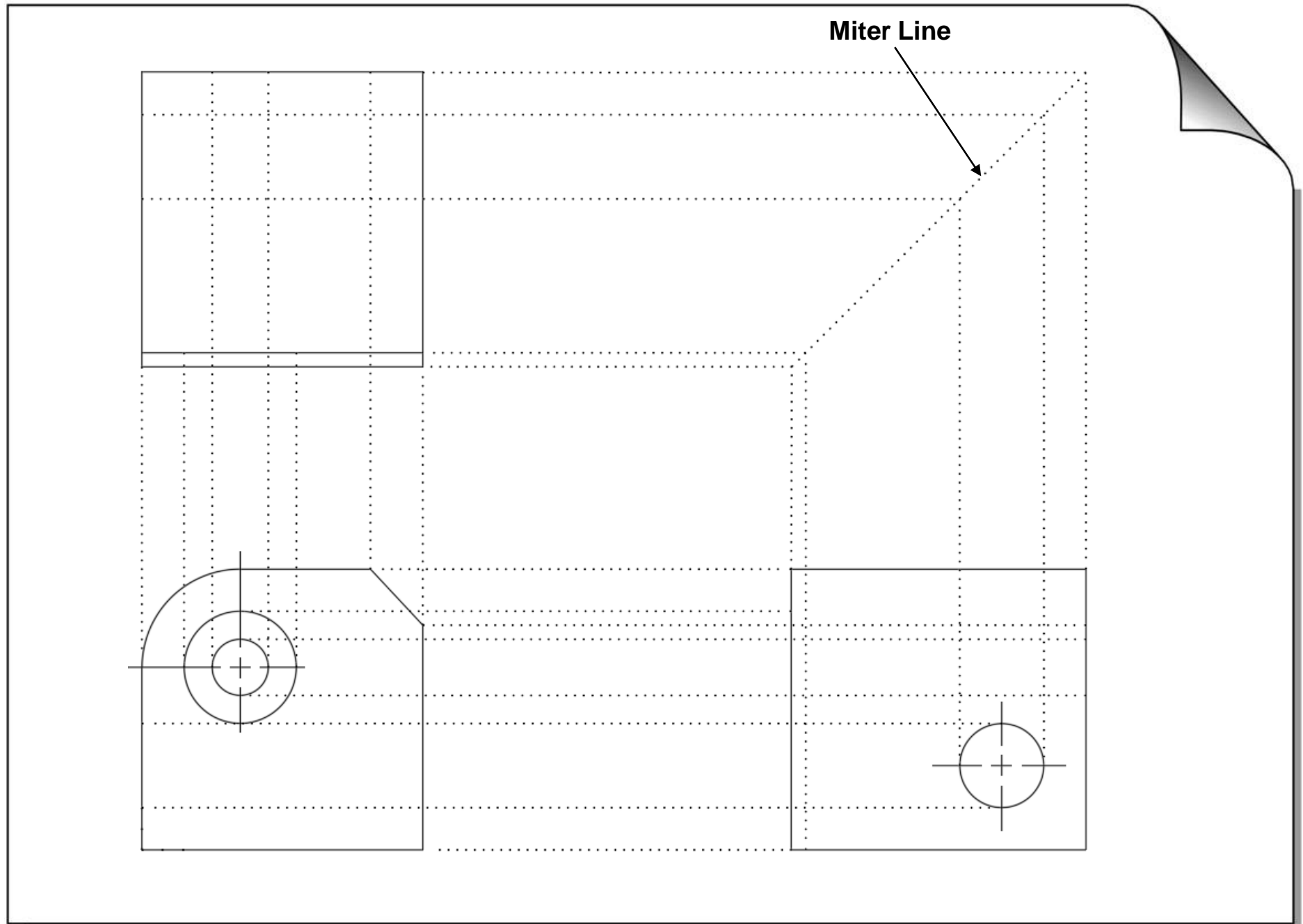
Step 1. Lightly “box in” the Width, Height, and Depth of the views using dimensions shown in **Figure 3.49**.



3.50(a) Boxing in the Width, Height, and Depth of the Views (Using Dimensions Shown in Figure 3.49)

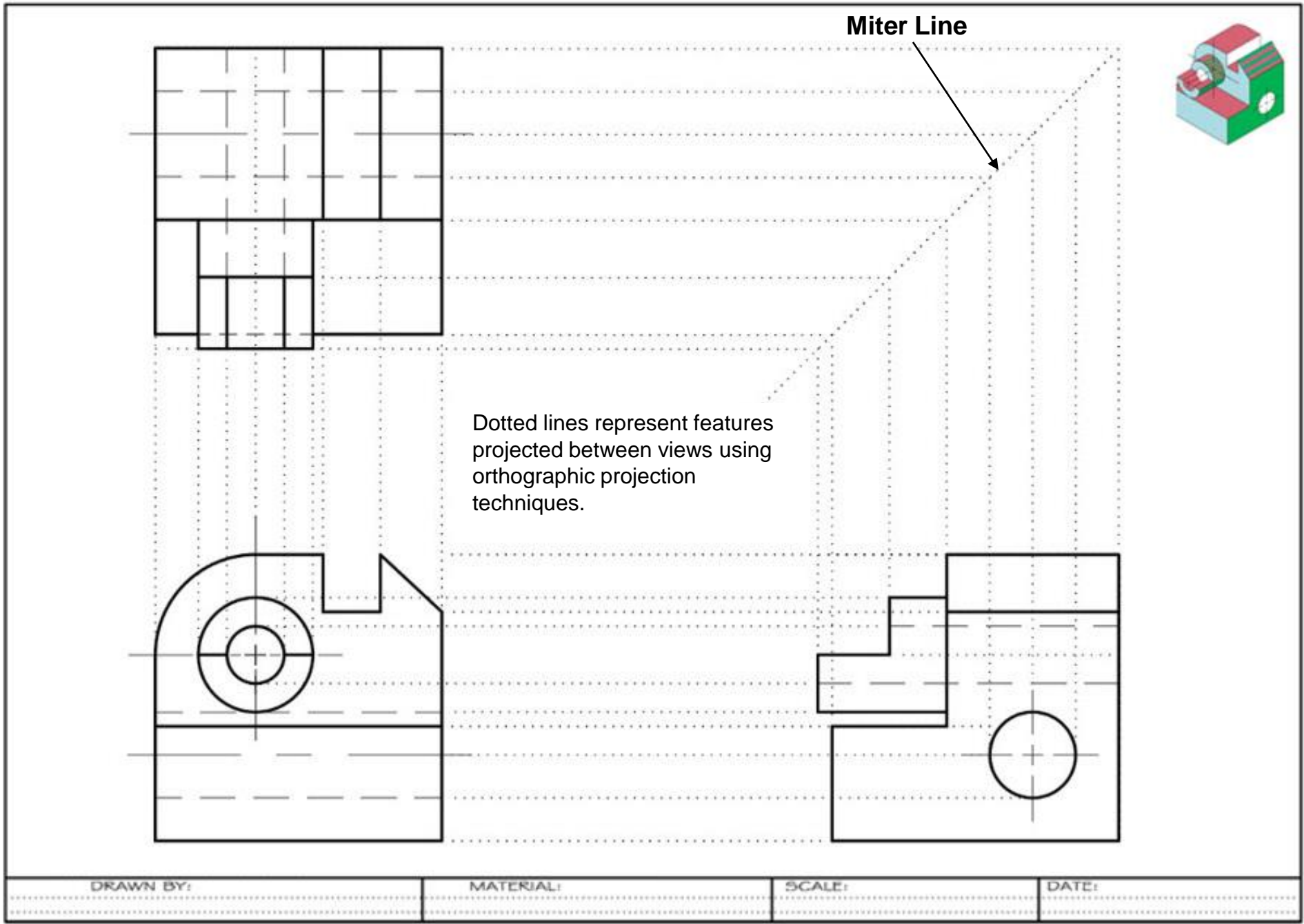


Step 2. Add features to the views. Apply orthographic projection techniques where possible.





Step 3. Project visible, hidden and center lines between views.

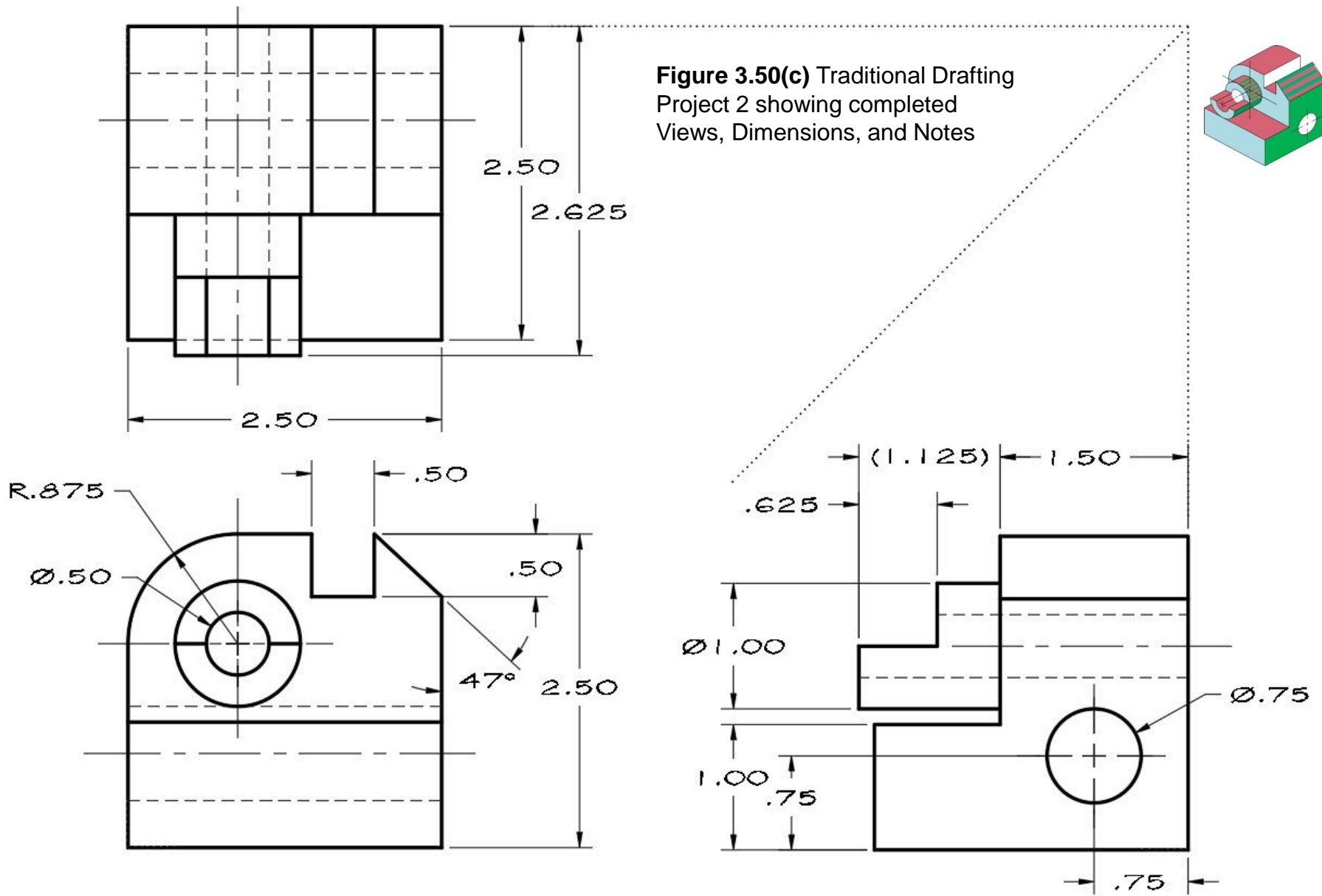
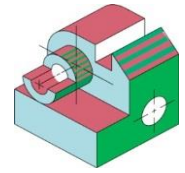


3.50(b) Projecting the Geometry of the Object's Features between the Views



Step 4. Add dimensions to views – draw guidelines before lettering text.

**Figure 3.50(c)** Traditional Drafting Project 2 showing completed Views, Dimensions, and Notes

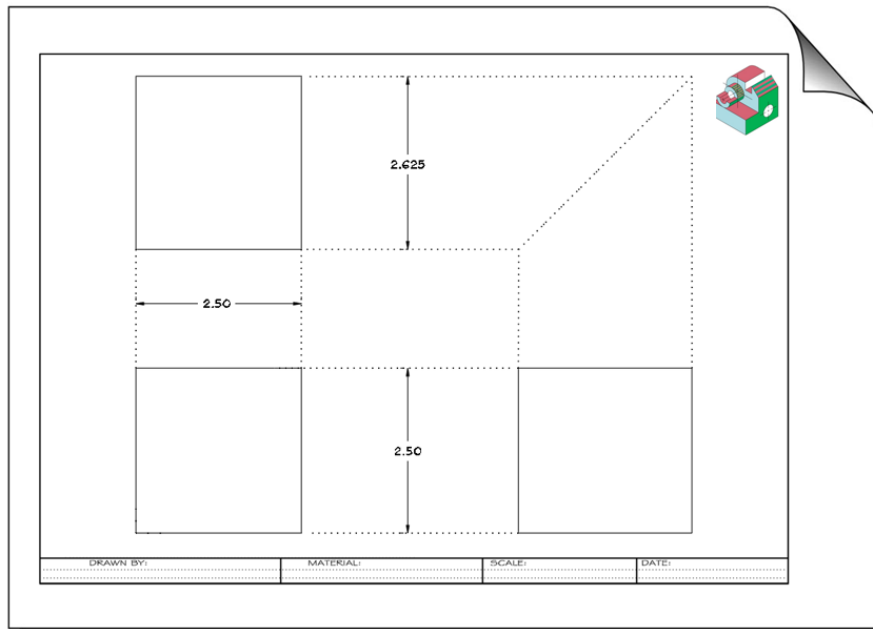


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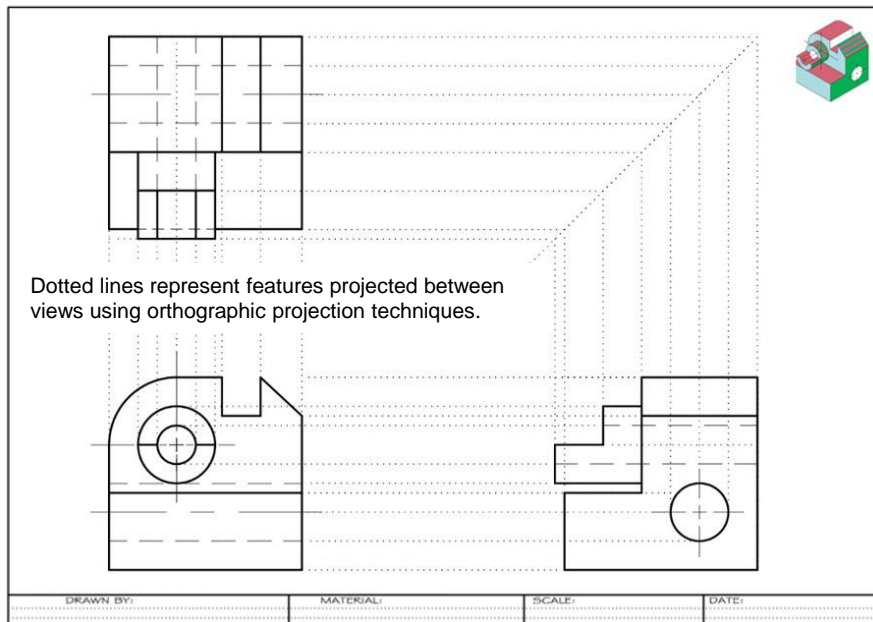
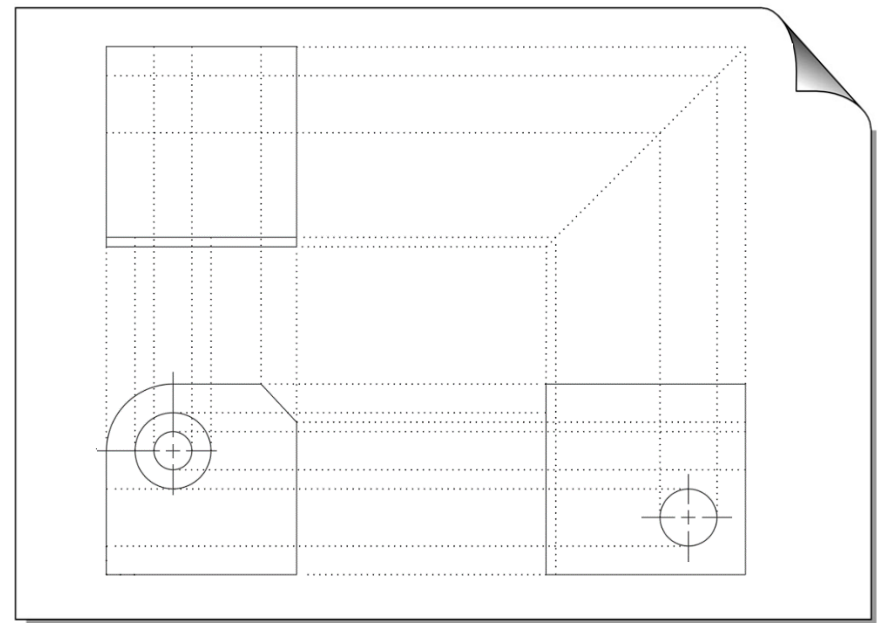


# Project 3-2 Traditional Drafting Project 2 – Help Sheet

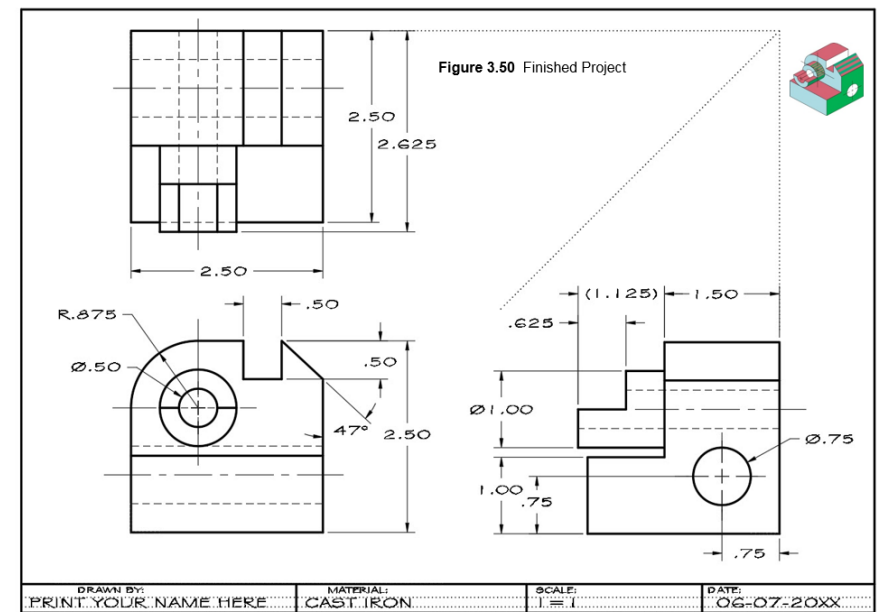
Step 1. Lightly "box in" the Width, Height, and Depth of the views using dimensions shown in **Figure 3.49**.



Step 2. Add features to the views. Apply orthographic projection techniques where possible.



Step 3. Project visible, hidden and center lines between views.



Step 4. Add dimensions to views – draw guidelines before lettering text.



# Alternative Architectural Traditional Drafting Project

## GUEST COTTAGE

•**Directions:** Print the *Cottage Project Sheet.pdf* file located inside the *Sketching and Lettering Plates* folder of this book's file downloads. These downloads are available by redeeming the access code that comes with this book. Please see the inside front cover of this book for further details.

Print the pdf "to fit" on a 17 X 11 size sheet.

Then draw the floor plan of the Guest Cottage. Using the Architects scale (refer to **Figure 3.19**), draw the plan at a scale of  $\frac{1}{4}" = 1'-0"$ . Draw the walls  $4\frac{1}{2}"$  wide.

Your instructor will provide an architectural template for adding the plumbing fixtures and doors.

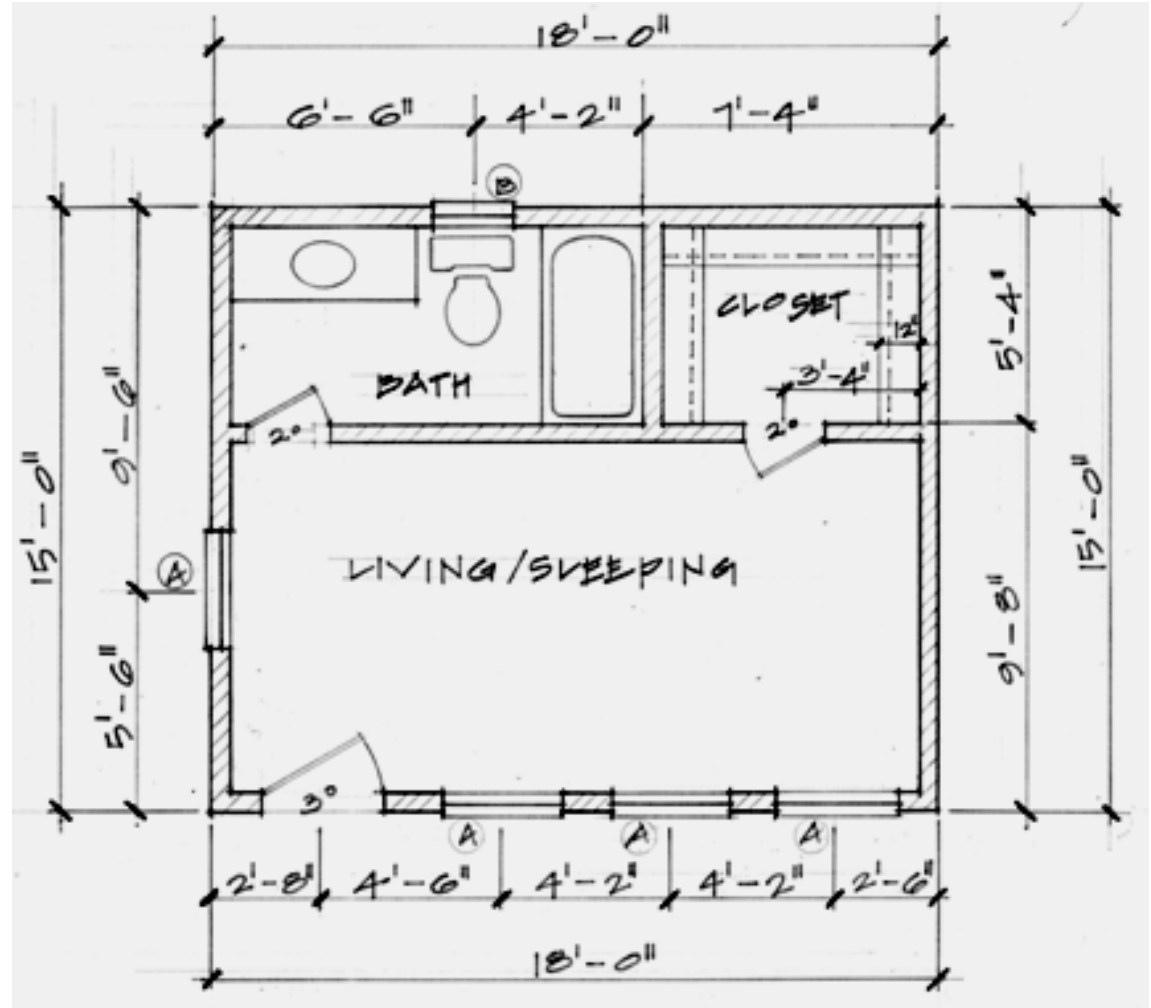
Apply dimensions as shown at right.

Fill in the window schedule as shown below.

Letter your name and scale in the guidelines provided.



WINDOW SCHEDULE			
MARK	SIZE	TYPE	QTY
A	3' x 3'	S.H	4
B	2' x 2'	S.H	1



WINDOW SCHEDULE			
MARK	SIZE	TYPE	QTY
A	3' x 3'	S.H	4
B	2' x 2'	S.H	1

NOTES: 1. WALL THICKNESS 4"

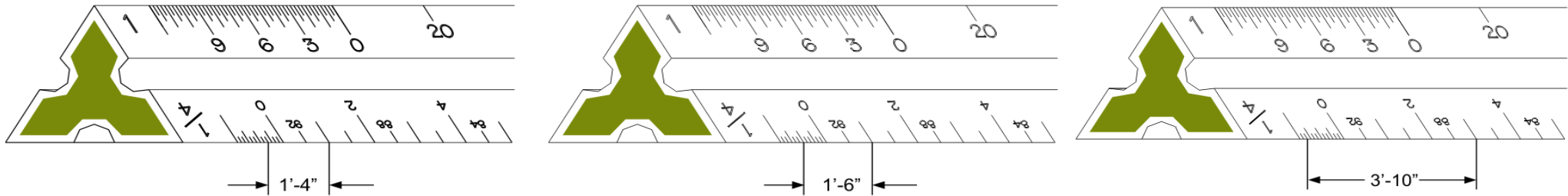
PROJECT NAME: GUEST COTTAGE  
 DRAWN BY: JENNY  
 DATE: 06-23-2012  
 SCALE:  $\frac{1}{4}" = 1'-0"$



## Reading the Architect's Scale

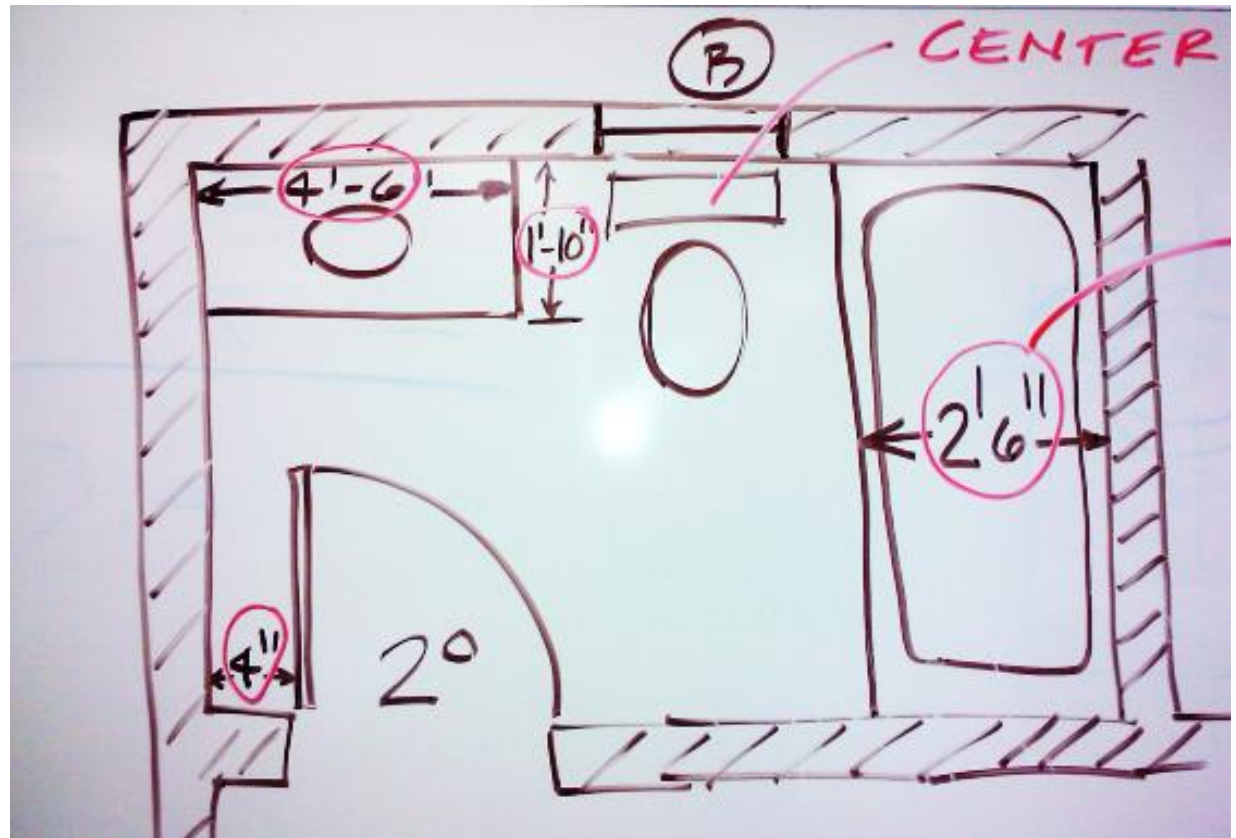
The Architect's scale is used to measure feet and inches on a floor plan. The **Architect's 1/4** scale shown in **Figure 3.19** would be interpreted as  $1/4" = 1'-0"$ . This means that  $1/4$  inch measured on the drawing would equal 1 foot at the construction site.

**Figure 3.19** Reading Feet and Inches on the Architect's  $1/4"$  equals 1' Scale



## Bathroom Fixtures

Use an Architectural Template to add the tub, toilet, and lavatory. See dimensions in sketches below. Do not include dimensions on drawing. Center the toilet on the window labeled B.



# GUEST COTTAGE SHEET LAYOUT

## FILE DOWNLOAD AVAILABLE FOR THIS PROJECT

The *Cottage Project Sheet.pdf* file used for the optional traditional drafting projects is located inside the *Sketching and Lettering Plates* folder of this book's file downloads. These downloads are available by redeeming the access code that comes with this book. Please see the inside front cover of this book for further details.

WINDOW SCHEDULE			
MARK	SIZE	TYPE	QTY
A			
B			

DRAW FLOOR PLAN  
AT 1/4" = 1'-0"

4"  
ACTUAL MEASUREMENT

3"  
ACTUAL MEASURE

STEP 1  
DRAW LIGHT CONSTRUCTION LINES TO "FRAME" THE SIZE OF THE FLOOR PLAN. DARKEN IT LATER.

PROJECT NAME:

DRAWN BY:

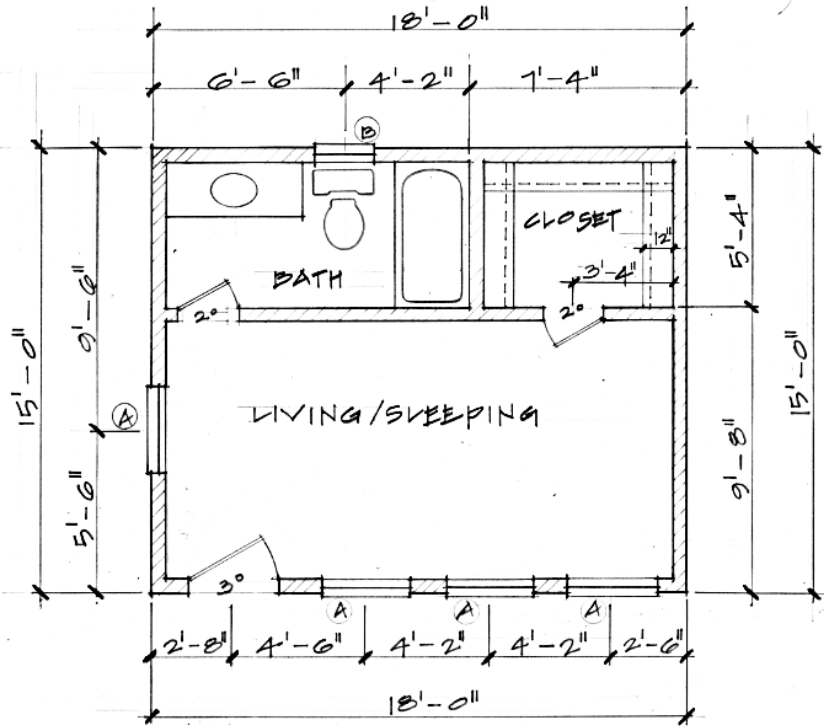
DATE:

SCALE:



# Guest Cottage-Traditional Drafting Project

Add the walls, bath fixtures, and dimensions to the floor plan as shown below.



WINDOW SCHEDULE			
MARK	SIZE	TYPE	QTY
A	3'0" x 3'0"	S.H	4
B	2'0" x 2'0"	S.H	1

NOTES: 1. WALL THICKNESS 4"

PROJECT NAME: GUEST COTTAGE		
DRAWN BY: JENNY	DATE: 06-03-2013	SCALE: 1/4" = 1'-0"



# Optional Traditional Drafting Projects

## •Directions for Optional Projects

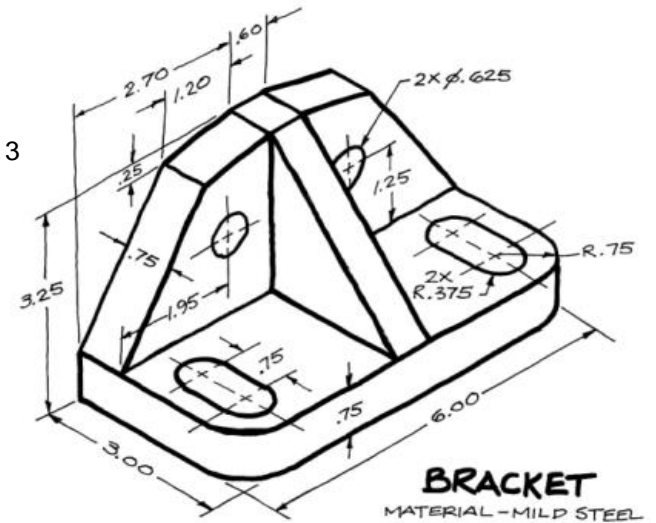
- Follow your instructor's directions to print copies of the *Traditional Drafting Sheet.pdf* file located inside the *Sketching and Lettering Plates* folder of this book's file downloads. Then, draw the front, top, and right views of the objects in Figures 3.51 through 3.53.
- Add dimensions to the views as instructed by your teacher. Letter your name, the material of the part, the date the drawing was created, and the drawing scale in the guidelines provided.
- Use the Engineer's 20 scale to draw the half-scale views of the object in Figure 3.51. Label the drawing scale in the title block as 1=2.
- Use the Metric 1:100 scale to draw the full-scale views of the object in Figure 3.52. Label the drawing scale in the title block as 1=1.
- Use the Engineer's 20 scale to draw the half-scale views of the object in Figure 3.53. Label the drawing scale in the title block as 1=2.

### FILE DOWNLOAD AVAILABLE FOR THIS PROJECT

The **Traditional Drafting Sheet.pdf** file used for the optional traditional drafting projects is located inside the *Sketching and Lettering Plates* folder of this book's file downloads. These downloads are available by redeeming the access code that comes with this book. Please see the inside front cover of this book for further details.

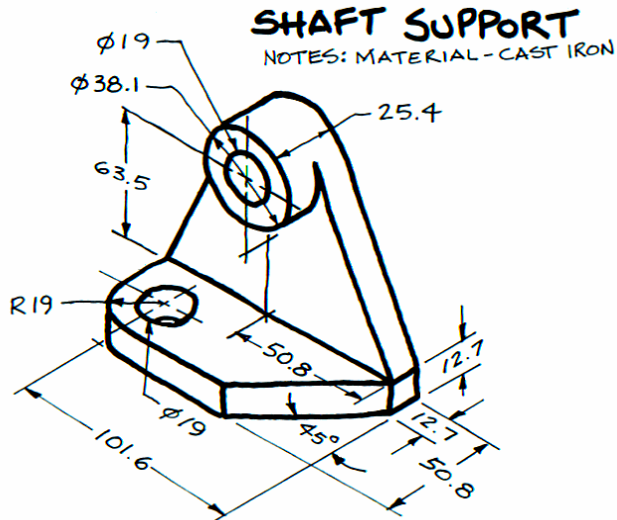
## Project 3-3

**Figure 3.51**  
Traditional Drafting Project 3



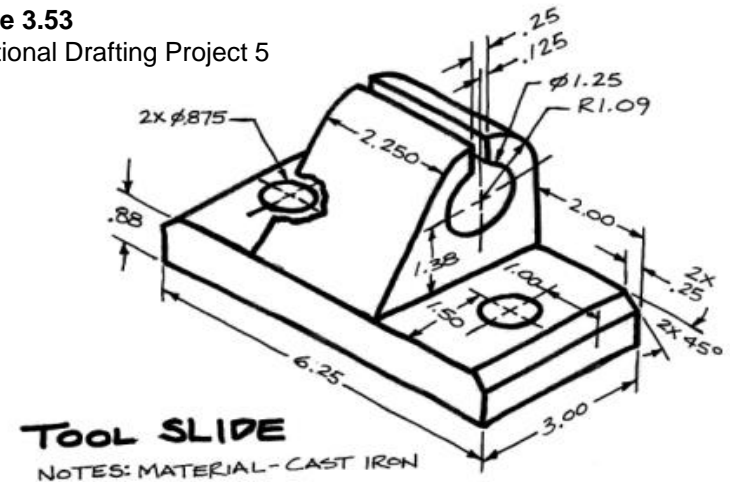
## Project 3-4

**Figure 3.52**  
Traditional Drafting Project 4



## Project 3-5

**Figure 3.53**  
Traditional Drafting Project 5

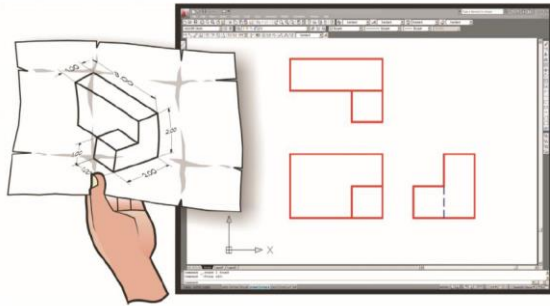






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CHAPTER

# 4

## COMPUTER - AIDED DESIGN BASICS

### Chapter Objectives

After studying the material in this chapter, you should be able to:

- Describe the AutoCAD interface and screen layout.
- Add toolbars and menus to the AutoCAD interface.
- Create, open, and save AutoCAD drawing files.
- Explain the coordinate system used to create AutoCAD drawings.
- Demonstrate how lines are drawn with AutoCAD using absolute, relative, and polar coordinates along with the direct entry method.
- Set the units, limits, layers, linetypes, and lineweights for an AutoCAD drawing.
- Create and edit AutoCAD drawings using AutoCAD's **Draw** and **Modify** commands.
- Employ **Object Snap** tools to facilitate accurate construction of AutoCAD drawings.
- Use the **Properties** tool to inquire about, or to change the properties of, an entity.
- Add text to a drawing and manage the text's height, font, and justifications settings.
- Create a new text style and edit text on a drawing.
- Create a floor plan for a small cottage.
- Create multiview drawings of machine parts.
- Plot AutoCAD drawings.

