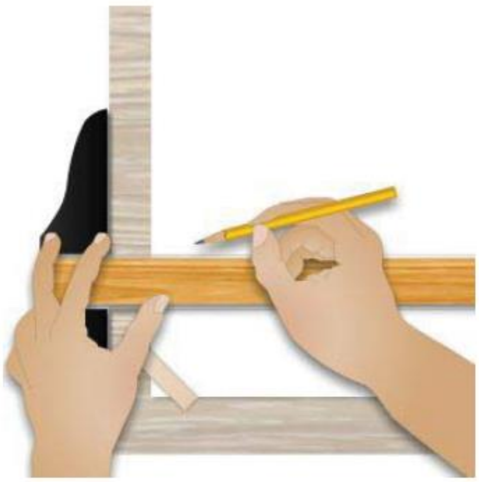


Student Handbook

For Basic Drafting

Drafting Media

The papers and films used to draw on are drafting media. While sketching may be done on any size piece of paper or on a variety of types of paper, all forms of architectural drafting, from technical sketching to mechanical drafting, are done on standard sizes and types of paper. There are two main types of paper, tracing and vellum, and there are drafting films such as Mylar and acetate. Tracing paper and drafting vellum are the two most widely used types of drafting media.

Tracing Paper

(Also called TRACE) is a medium-grade white (or slightly yellow tinted) transparent paper that takes pencil, ink and marker well. Trace is typically used for sketching and developing ideas, developing initial and preliminary layouts and developing space planning. It is an inexpensive paper and, since it is transparent, a new sheet can be placed over a preliminary drawing to refine it. It is easier and neater to do this than to erase and redraw lines on the original. Some designers use trace for presentations in the early phase of a design project, then, when the designs are approved and fully developed, they are transferred to vellum.

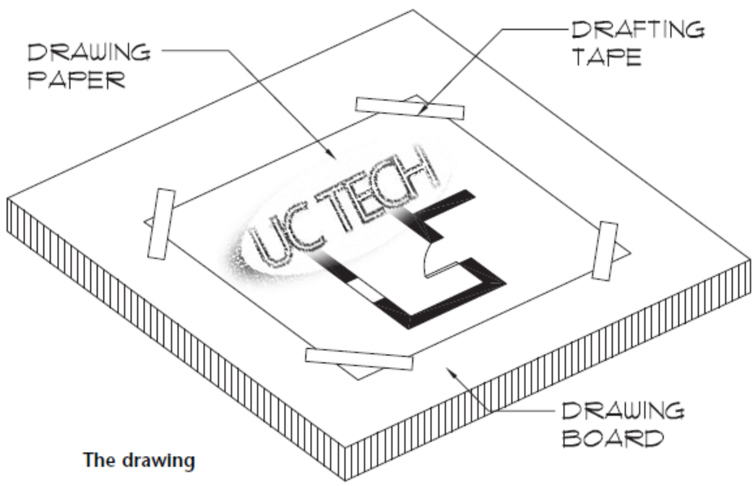
Drafting Vellum

(Also called TRACING VELLUM) is a high-grade white (or slightly tinted) transparent paper that takes pencil well, and from which pencil lines can be easily erased. Reproductions can be made directly from pencil drawings on drafting vellum. Vellum also takes pen and ink well. On most papers, ink will bleed (that is spread and absorb into the paper). Ink lines on vellum are crisp and solid as it does not absorb the ink readily; however, caution must be taken to not unintentionally smear the ink before it dries.

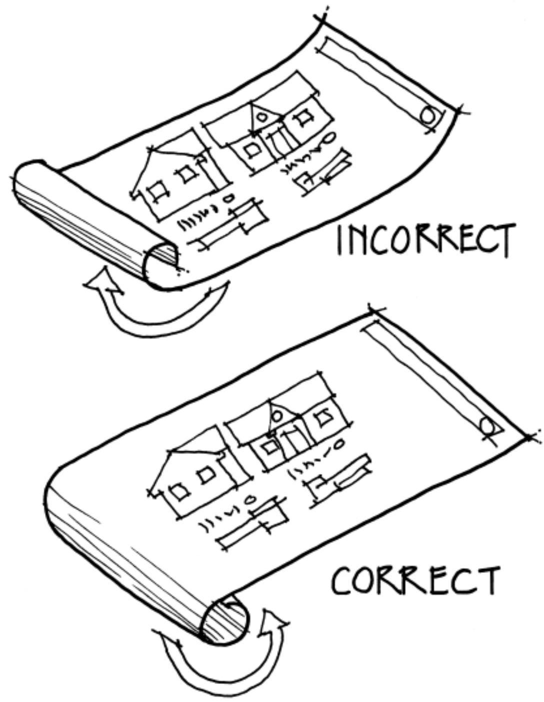
GRID or GRAPH PAPER

Available in a variety of grid patterns, most grid media used in design has 4 squares per inch. This can represent 1/4 scale for drawing purposes. It is used for planning, drawing, rough design sketching, technical sketches, or simply under a sheet of trace as a guide.

DRAFTING SHEET SIZES



The drawing paper is held in place on the drawing surface with small pieces of drafting tape.



Most drafting media are available in three styles: **rolls, plain sheets, and preprinted sheets** with borders and title blocks. There are also sheets available with non-photo blue (a light blue color that does not reproduce when making plan reading and drafting) grids.

According to **ANSI** (*American National Standards Institute*) in the United States an 8.5 x 11 inch piece of paper is an engineering ‘A” size sheet. This is typically referred to as letter size. The ‘B” size sheets are 11 x 17 and are typically referred to as a “tabloid” size sheet of paper. The ‘C” size sheets are 18 x 24 inches and the D” size sheets are 24 x 36 inches. Most drafting for design purposes is done on the B, C, and D size sheets. The decision for choosing a size should be based on project requirements, the scale of the drawings, and the scope and size of the final structure. Trace and vellum maybe purchased on rolls that require sizing the paper properly. Trace may be sized by measuring the length needed and using a straight edge, T-square, or parallel rule to rip the paper off of the roll. Trace rips easily and slightly rough edges are expected. Vellum from a roll should be measured to its proper length and then using a straight edge and an X-Acto knife on a proper cutting surfaces trim the paper to its proper length. Scissors should never be used in cutting trace or vellum.

PAPER SIZES

SIZE	ENGINEERING	ARCHITECTURAL
A	8.5" X 11"	9" X 12"
B	11" X 17"	12" X 18"
C	17" X 22"	18" X 24"
D	22" X 34"	24" X 36"
E	34" X 44"	36" X 48"

Drafting Pencils

Two types of pencils are used in drafting: **wooden and mechanical**. The latter is actually a lead holder and may be used with leads of different hardness or softness. Drafting pencils are graded according to the relative hardness of their graphite lead. A soft pencil is designated by the letter B, a hard pencil by the letter H. Figure 3-6 shows 17 common grades of drafting pencils from **6B (the softest and the one that produces the thickest line) to 9H (the hardest and one that produces a thin, gray line).** You will notice that the diameters of the lead vary. This feature adds strength to the softer grades. As a result, softer grades are thicker and produce broader lines, while harder grades are smaller and produce thinner lines. Unfortunately, manufacturers of pencils have not established uniformity in grades. Hence, a 3H may vary in hardness from company to company. With experience and preference, you may select the trade name and grade of pencil that suits your needs.

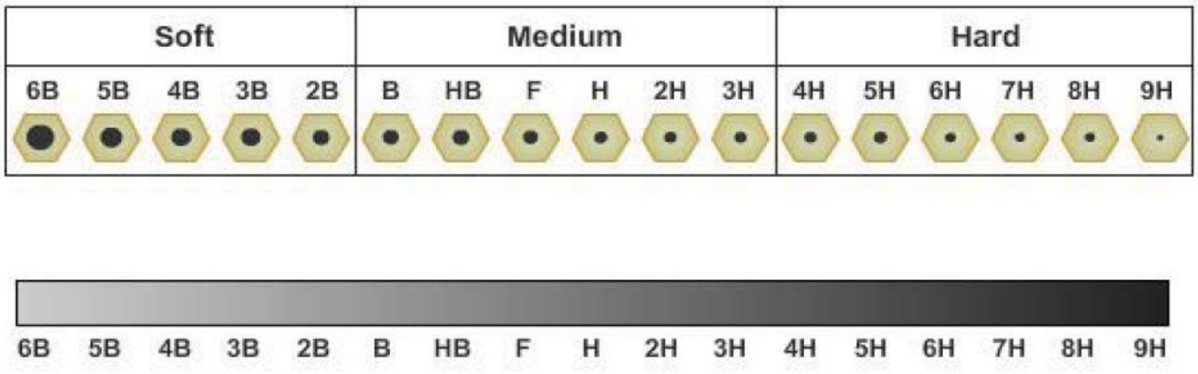


Figure 3-6

Erasers and Erasing Accessories

You must be very careful in selecting an eraser to select one that will remove pencil or ink lines without damaging the surface of the drawing sheet.

A **vinyl eraser** is ideal for erasing lines drawn on tracing cloth and films. An ordinary double-beveled pencil eraser generally comes in red or pink color (sometimes called a pink pearl). A harder eraser (sometimes called a ruby red) is designed for erasing lines in ink. The art gum eraser, made of soft pliable gum, will not mar or scratch surfaces. It is ideally suited for removing pencil or finger marks and smudges. You can also use a kneaded eraser—the type used by artists. It is a rubber dough, kneadable in your hand, and has the advantage of leaving very little debris on the drawing sheet.

When there are many lines close together only one of which needs removing or changing, you can protect the desired lines with an erasing shield, as shown in Figure 3-8.

Figure 3-8 – Eraser shield.

T Squares

The **T square** gets its name from its shape. It consists of a long, straight strip, called the **blade**, which is mounted at right angles on a short strip called the **head**. The head is mounted under the blade so that it will fit against the edge of the drawing board while the blade rests on the surface. T squares vary in size from 15 to 72 inches in length, with 36 inches the most common.

The T square shown in Figure 3-10 is typical of the ones used by designers and drafters. The head is made of hardwood, the blade usually of maple with a natural or mahogany finish.

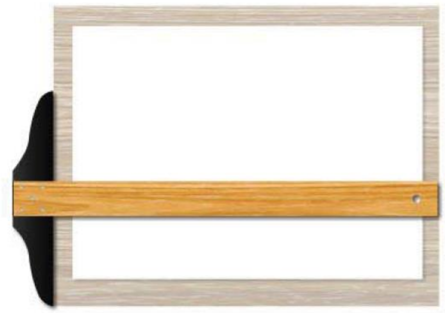


Figure 3-10 – Drafting board with T square and drafting paper in place

Triangles

Triangles are used in combination with the T square or straightedge to draw vertical and inclined lines. They are usually made of transparent plastic, which allows you to see your work underneath the triangles. Triangles are referred to by the size of their acute angles. Figure 3-13 shows two basic drafting triangles: the 45^0 **(each acute angle measures 45^0, and the $30^0/60^0$** (one acute angle measures 30^0; the other, 60^0). The size of a 45^0 triangle is designated by the length of the sides that form the right angle (the sides are equal). The size of a $30^0/60^0$ triangle is designated by the length of the longest side that forms the right angle. Sizes of both types of triangles range from 4 inches through 18 inches in 2-inch increments.

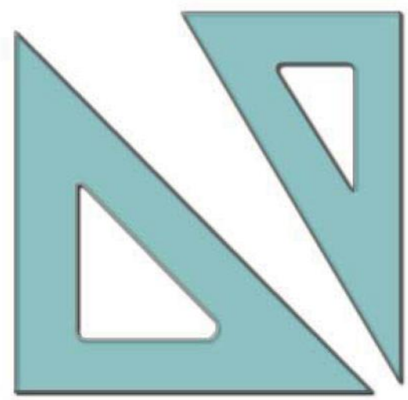


Figure 3-13 – 45° and 30°/60° drafting triangles.

Protractors

Protractors are used for measuring and laying off angles other than those drawn with the triangle or a combination of triangles. Most of the work you will do with a protractor will involve plotting information obtained from field surveys. Like the triangle, most protractors are made of transparent plastic. They are available in 6-, 8-, and 10-inch sizes and are either circular or semicircular in shape, as shown in Figure 3-15.

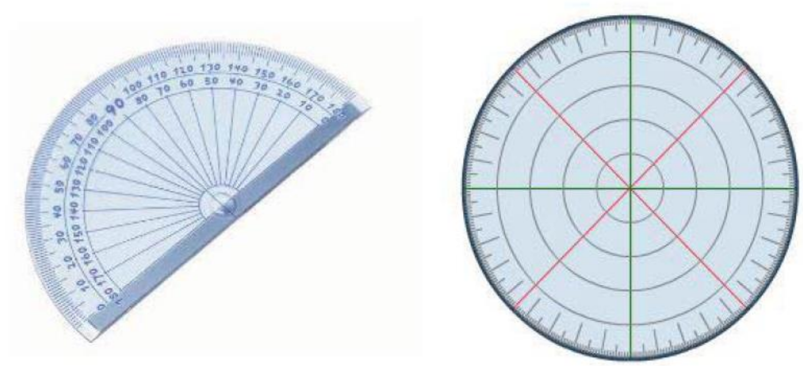
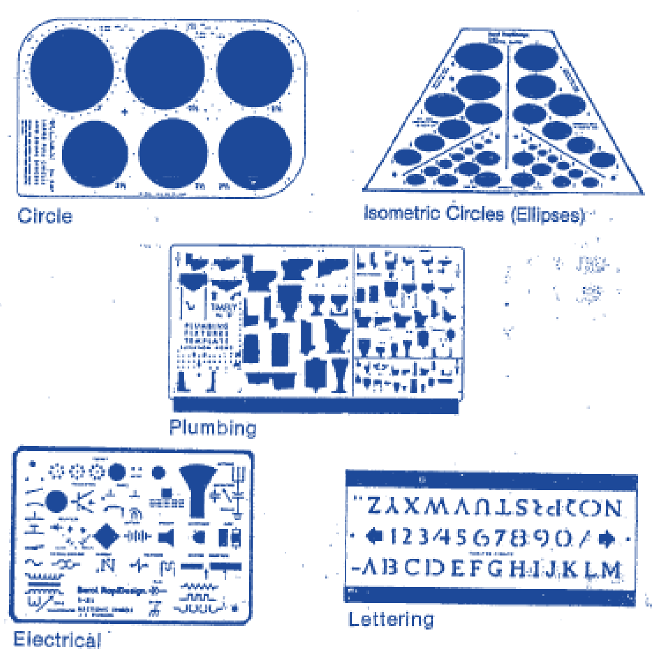


Figure 3-15 – Types of protractors.

TEMPLATES

Though there are a variety of templates available today, they all exist to serve the same purpose, that is, to speed drawing time and assure consistency and accuracy in the finished work Most templates are made of very thin " eye saving", green; plastic and have holes or designs milled or molded into them. Some have raised or textured surfaces and are utilized by placing them under the drawing and rubbing over (burnishing) with a soft lead to create continuous repetitive details such as brick or roofing on architectural drawings. The majority of templates however, are used by simply tracing around the holes or designs that are cut in them to transfer that symbol to your finished drawing. Templates come in many sizes and shapes to match the scale being used on the drawing; some are shown here.



Various types of Templates

Adjustable Triangles

The **adjustable triangle,** shown in Figure 3-16, combines the functions of the triangle and the protractor. When it is used as a right triangle, you can set and lock the hypotenuse at any desired angle to one of the bases. The transparent protractor portion is equivalent to a protractor graduated in $1/2^0$ increments. The upper row of numbers indicates angles from 0^0 to 45^0 to the longer base; the lower row indicates angles from 45^0 to 90^0 to the shorter base. By holding either base against a T square or straightedge, you can measure or draw any angle between 0^0 and 90^0.

Figure 3-16 – Adjustable triangle.

The adjustable triangle is especially helpful in drawing building roof pitches .It also allows you to transfer parallel inclined lines by sliding the base along the T square or straightedge.

French Curves

Use **irregular curves** (called french curves) for drawing smooth curved lines other than arcs or circles, lines such as ellipses, parabolas, and spirals. Transparent plastic french curves come in a variety of shapes and sizes. Figure 3-17 shows an assortment of french curves. In such an assortment, you can find edge segments you can fit to any curved line you need to draw. Stow and care for french curves in the same manner as triangles.

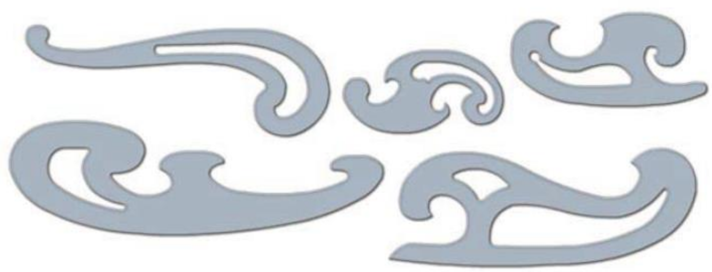


Figure 3-17 – French curves.

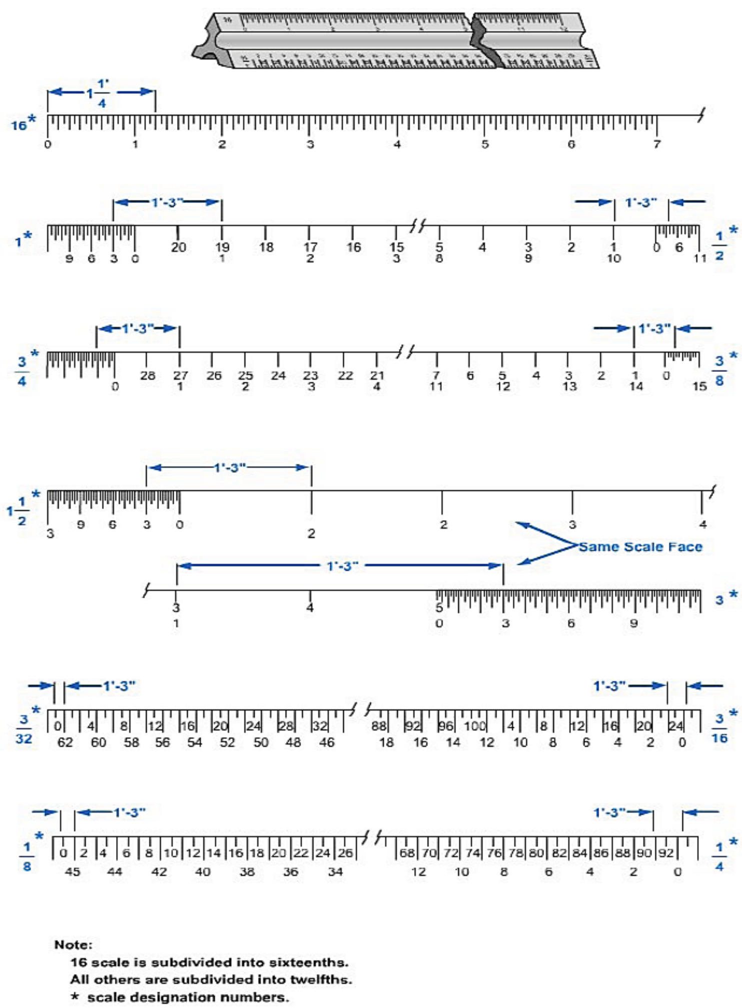
Drawing Instrument Sets

So far we have discussed only those instruments and materials you will need for drawing straight lines (with the exception of french curves). Many drawings you prepare will require circles and circular arcs. Use instruments contained in a drawing instrument set for this purpose. Many types of drawing instrument sets are available; however, it is sometimes difficult to judge the quality of drafting instruments by appearance alone. Often their characteristics become evident only after use. The drawing instrument set shown in Figure 3-19 is typical of sets in the standard draftsman kit. The following sections describe these instruments as well as some special-purpose instruments not found in the set. These special-purpose instruments may be purchased separately or found in other instrument sets.

Figure 3-19 – Bow instruments: bow pen/pencil; bow divider, bow drop pen drawing instrument set

Architect's Scale

Architect's scales are usually triangular and are used wherever dimensions are measured in feet and inches. Major divisions on the scale represent feet; those divisions are subdivided into 12ths or 16ths, depending on the individual scale. Figure 3-29 shows the triangular architect's scale and segments of each of the eleven scales found on this particular type of scale. Notice that all scales except the 16th scale are actually two scales read either from left to right or right to left. When reading a scale numbered from left to right, notice that the numerals are closer to the outside edge. On scales numbered from right to left, notice that the numerals are closer to the inside edge.

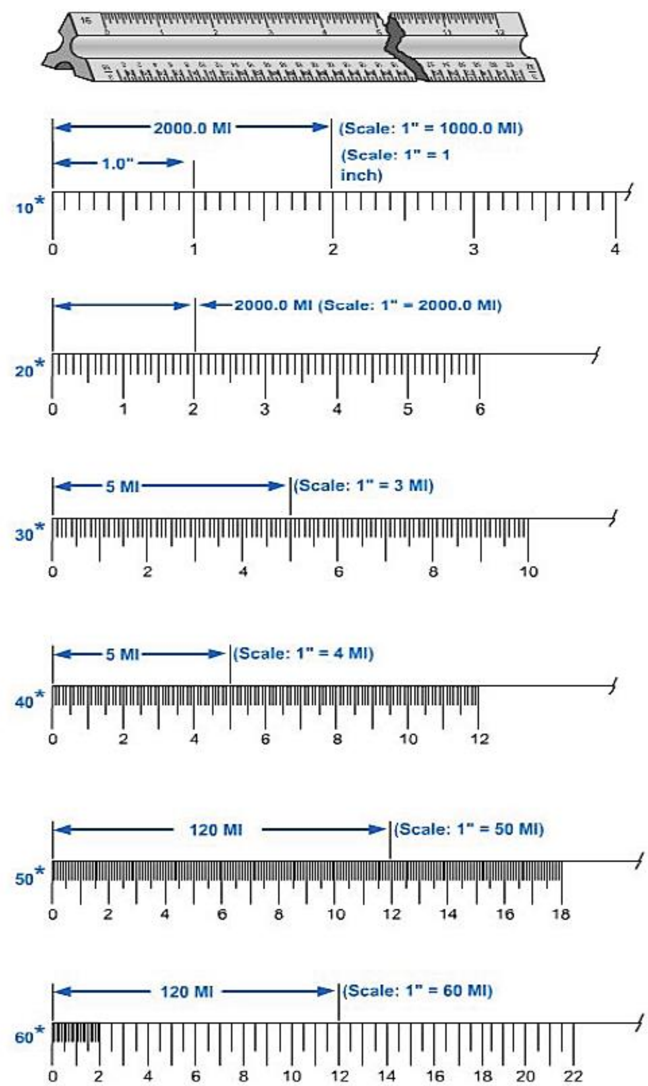


3 inches = 1 foot
1 ½ inches = 1 foot
1 inch = 1 foot
¾ inch = 1 foot
½ inch = 1 foot
3/8 inch = 1 foot
¼ inch = 1 foot
1/16 inch = 1 foot
1/8 inch = 1 foot
3/32 inch = 1 foot

Figure 3-29 – Architect's scale.

Engineer's Scale

The chain or civil engineers, scale, commonly called the engineer's scale, is usually a triangular scale, containing six fully divided scales subdivided decimally, each major interval on a scale being subdivided into 10ths. Figure 3-30 shows the engineer's scale and segments of each of the six scales. Each of the six scales is designated by a number representing the number of graduations that particular scale has to the linear inch. On the 10 scale, for example, there are **10 graduations to the inch**; on the 50 scale, there are 50. You can see that the 50 scale has 50 graduations in the same space occupied by 10 on the 10 scale. This space is 1 linear inch.



lote:
Each scale is a multiple of ten.
* scale designation numbers.

Figure 3-30 – Engineer's scale.

Horizontal Lines

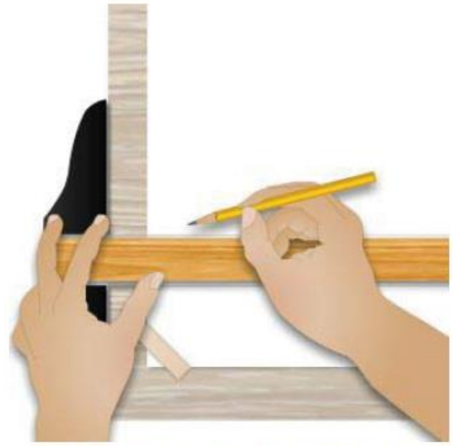


Figure 4-3 – Construction of a horizontal line.

As a designer, you will construct a horizontal line by drawing from left to right along the working edge of a T square, as shown in Figure 4-3. This working edge, when true, is perpendicular to the working edge of the drafting board. When you draw horizontal lines, keep the working edge of the T square head in firm contact with the working edge of the drafting board. Incline your pencil to the right at an angle of about 60 degrees with the point close to the junction of the working edge and the paper. Hold the pencil lightly and, if it was sharpened with a conical point, rotate it slowly while drawing the line to achieve a uniform line width and preserve the shape of the point. **Normally, when you are drawing a series of horizontal lines, start from the top and work your way down.**

Vertical Lines

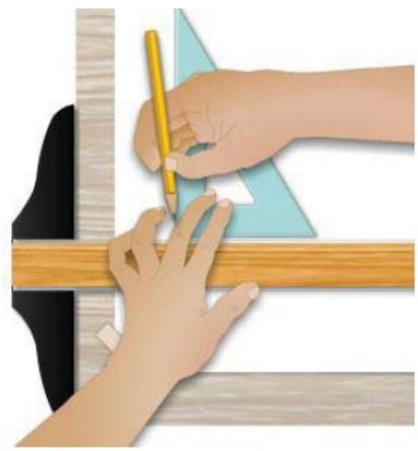
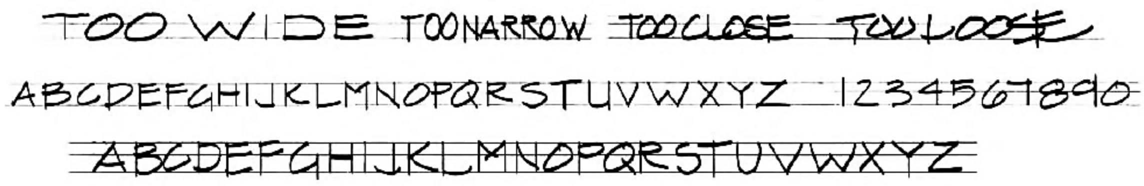


Figure 4-4 – Construction of a vertical line.

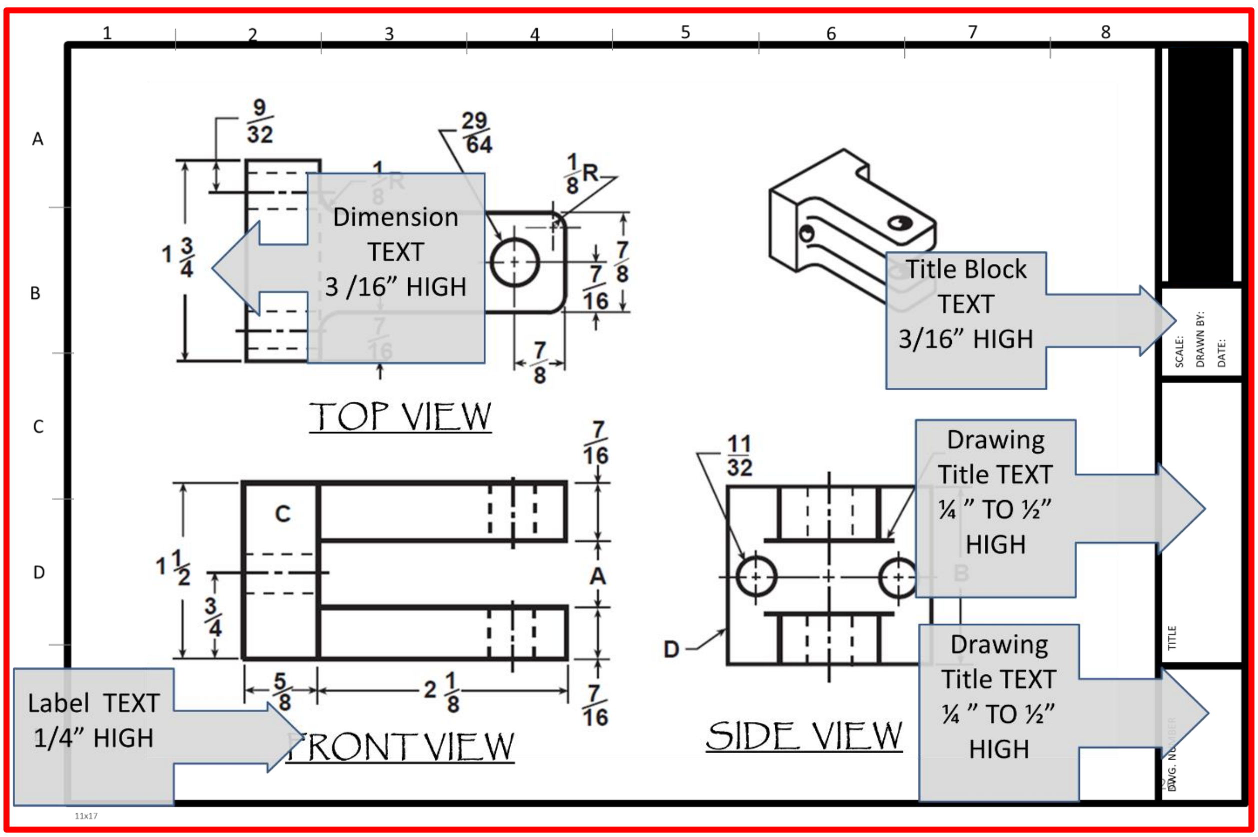
You will create vertical lines parallel to the working edge of the drafting board by using triangles in combination with a T square. Place one leg of a triangle against the working edge of the blade so that the other leg faces the working edge of the board to prevent casting a shadow over your work. Draw lines from the bottom up, as shown in **Figure 4-4**. Incline your pencil toward the top of the working sheet at an angle of approximately 60 degrees, with the point as close as possible to the junction of the triangle and the drafting paper. When drawing a series of **vertical lines, start from the left and work your way to the right.** Never use the lower edge of the T square blade as a base for triangles.

Lettering Methods

The draftsperson must endeavor to keep the letters within the top and bottom lines, and not let parts of the letters extend beyond these. In most cases, the guidelines are produced with such a light line that they are left in and not erased. In pen and ink drawing, these lines might be laid out in no reproducible blue pencil lines.



In order to make words and letters in drawings quickly and easily understood, a universal style of lettering is used that is usually done in all capital letters.



Lettering Text heights on drawings

Alphabet of Lines

In industrial manufacturing, production personnel, product designers and manufacturing engineers must all speak the same language if the finished product is to look like the one needed. The product dimensions tolerances, material callouts, assembly directions and other information must be clearly understood.

The language that is used in manufacturing is not a spoken language, but a language of lines, numbers, symbols and illustrations. It is a graphic language that is drawn and read rather than spoken and heard. It is the language of plan reading and drafting where pictorial representations replace written instructions, and descriptions are expressed in graphic form.

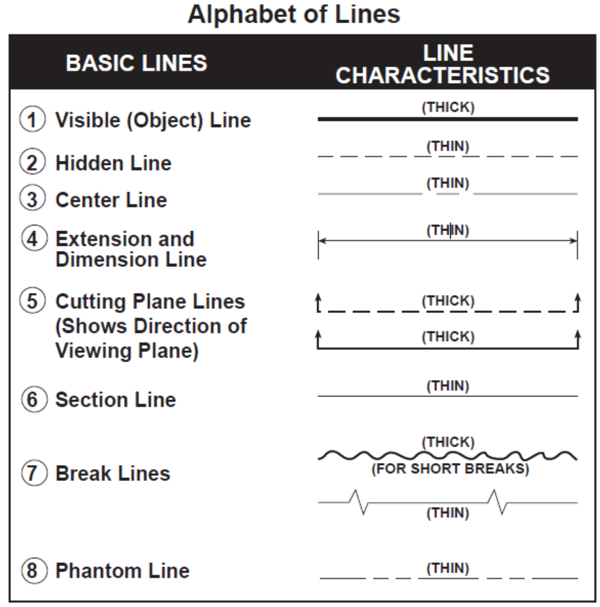
A blueprint can take many different forms according to its purpose and the people who use it. Examples of these different forms include:

- Drawings for fabrication with standardized symbols for mechanical, welding, construction, electrical wiring and assembly.

- Sketches that illustrate an idea, technical principle or function.

The ability to read and interpret drawings and plan reading and drafting depends on the ability to recognize the different types of lines used in making the drawings, and to understand how these lines describe the object or parts represented. Lines used to represent an object and to aid in reading the drawing are made in defnite standard forms. The relative thickness of a line, (thick or thin) and the line's composition—solid, broken, dashed—have specifc meanings.

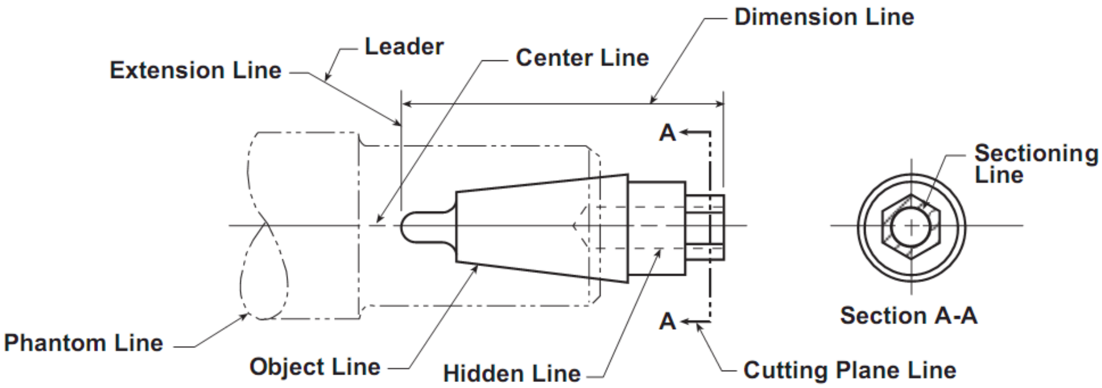
FIGURE 1-1
Alphabet of Lines



As with each letter in the alphabet, each line in the Alphabet of Lines has a designated purpose in the language of plan reading and drafting. The most obvious reason for a line appearing in a drawing is to define the shape of an object.

As with each letter in the alphabet, each line in the Alphabet of Lines has a designated purpose in the language of plan reading and drafting. The most obvious reason for a line appearing in a drawing is to define the shape of an object. Lines are used for many other purposes, however, and the ability to recognize the type and purpose of a line in a drawing is the first step in becoming a good blueprint reader. Figure 1-2 provides examples of each type of line in the Alphabet of Lines. Definitions for each type of line follow the drawing.

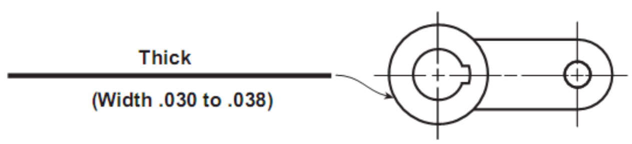
FIGURE 1-2
Examples of Line Types



1. Object Lines

Object or visible lines (see Figure 1-3) are thick solid lines that outline all surfaces visible to the eye. These are the most important lines because they are thick and solid and thus become the basis for comparing the weights and composition of all other lines used in a drawing.

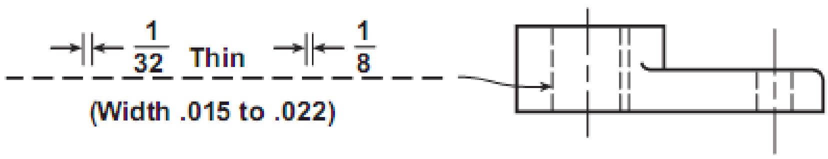
FIGURE 1-3
Object Line



2. Hidden Lines

Hidden or invisible lines, consisting of short, evenly-spaced dashes, outline invisible or hidden surfaces. They are thin lines, about half as heavy as visible lines. They always begin with a dash in contact with the line from which they start, except when a dash would form a continuation of a solid line. A hidden line is shown in Figure 1-4.

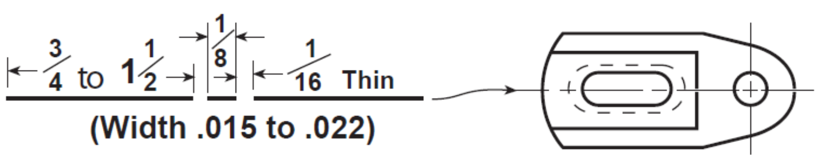
FIGURE 1-4
Hidden Lines



3. Center Lines

Center lines (see Figure 1-5) consist of alternating long and short, evenly-spaced dashes, with a long dash at each end and short dashes at points of intersection. The lines are the same weight as invisible lines. Center lines indicate the central axis of an object or part, particularly circular objects or objects made up of circular or curved parts. They are also used to indicate the travel of a center. Whenever a complete circle or hole is shown on a drawing, both horizontal and vertical center lines are used to indicate the center point of the circle or hole.

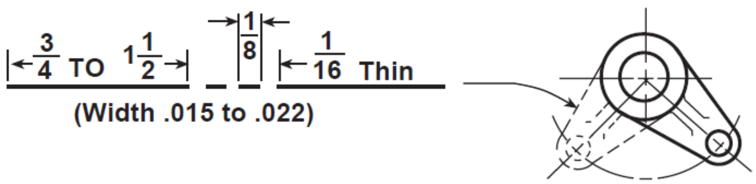
FIGURE 1-5
Center Line



4. Phantom Lines

Phantom lines (see Figure 1-6) are thin lines used to indicate alternate positions of the parts of an object, repeated detail or the locations of absent parts. They are made by alternating one long and two evenly-spaced, short dashes, with a long dash at each end.

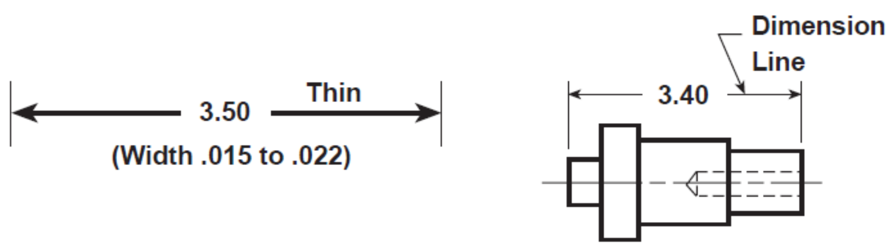
FIGURE 1-6
Phantom Lines



5. Dimension Lines

Dimension lines (see Figure 1-7) are short, solid lines that indicate the distance between two points on a drawing. They terminate or end in arrowheads at each end, and are broken to insert the dimension.

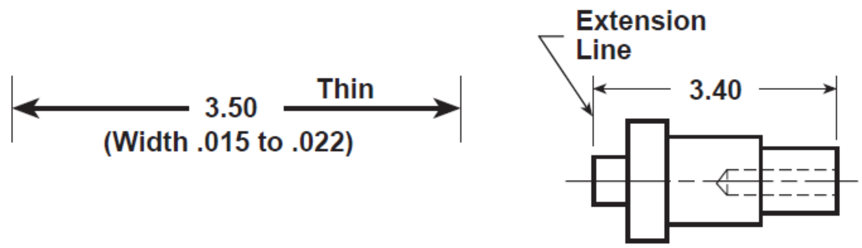
FIGURE 1-7
Dimension Lines



6. Extension Lines

Extension lines (see Figure 1-8) are short, solid lines used to show the limits of dimensions. They may be placed inside or outside the outline of an object. They extend from an outline or surface, but do not touch it. Extension lines are the same weight as invisible lines.

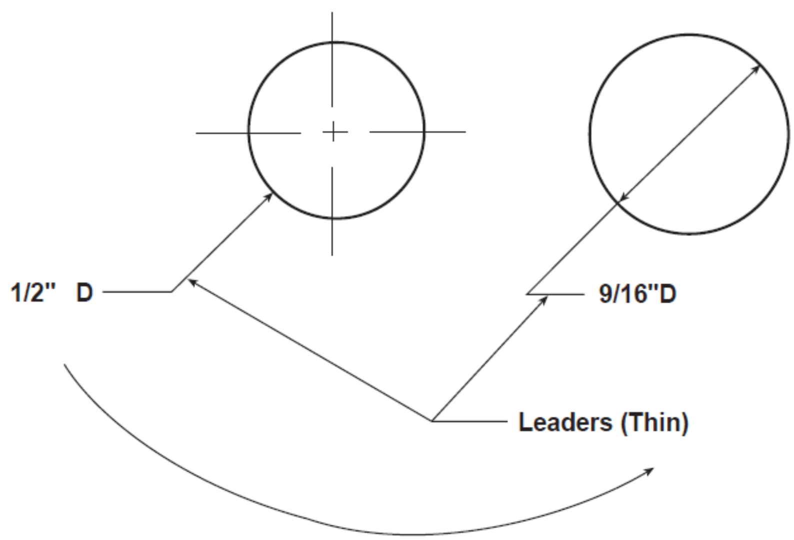
FIGURE 1-8
Extension Lines



7. Leaders

Leaders or leader lines (see Figure 1-9) indicate the part or area of a drawing to which a number, note or other reference applies. They are solid lines and usually terminate in a single arrowhead.

FIGURE 1-9
Leaders



8. Break Lines

There are long and short break lines (see Figure 1-10). These indicate that a part is broken out or removed to show more clearly the part or the parts that lie directly below the broken out part. They also are used to reduce the size of the drawing of a long part having a uniform cross section so that it can be shown on a smaller sheet of paper. Short breaks are indicated by solid, thick, freehand lines. Long breaks are indicated by solid, thin, ruled lines broken by freehand zigzags. Breaks on shafts, rods, tubes, and pipes are curved (see Figure 1-11).

FIGURE 1-10
Long-break Line

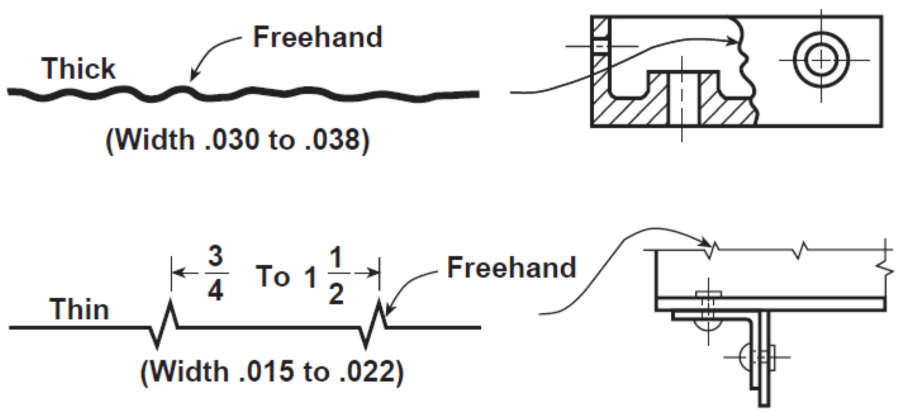
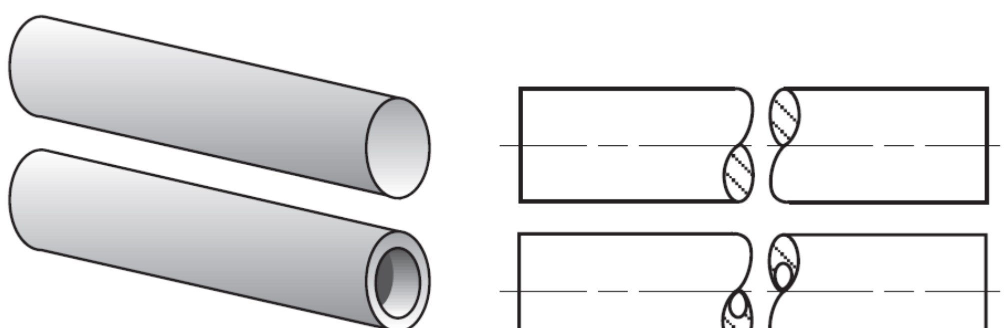


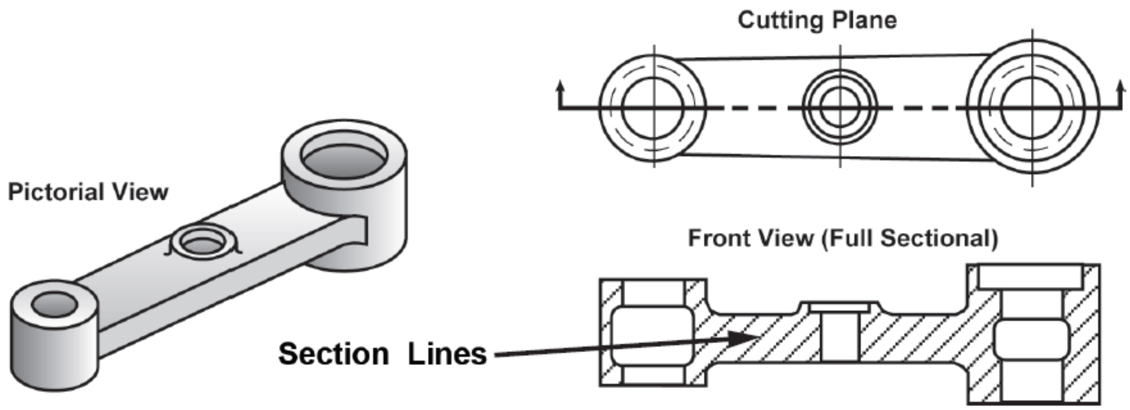
FIGURE 1-11
Round, Solid, Hollow Cross-Sections



9. Section Lines

Section lines (see Figure 1-12) or crosshatch lines distinguish between two separate parts that meet at a given point. Each part is lined or hatched in opposite directions with thin parallel lines placed approximately 1/16 inch apart at 30 degrees, 45 degrees, or 60 degrees across the exposed cut surface. Most section lines follow this pattern.

FIGURE 1-12
Section Lines

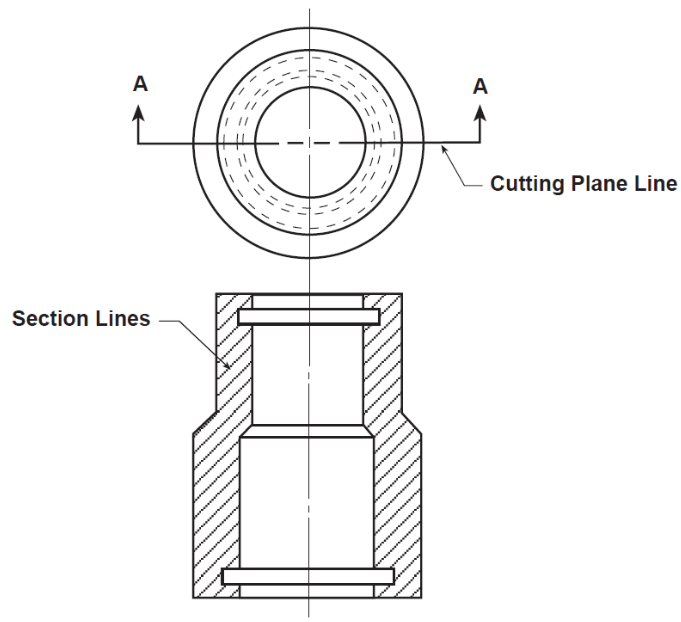


Section lines are also used to depict specific types of materials used in the part or subject of the drawing. The lines in the previous drawing represent cast iron but are used generally to show any cut or sectioned surface. If there is a need to represent a variety of materials or if a specific material must be used, individual parts within the drawing may be lined or crosshatched using different patterns for the various materials. Patterns used to represent some of the more common materials used in manufacturing are shown in Figure 1-13.

10. Cutting Plane Lines

A cutting plane line (see Figure 1-14) consists of a heavy dash followed by two shorter dashes. At each end, it has a short line at right angles to the cutting plane line terminating with arrowheads pointing in the direction from which the cut surface is viewed. Cutting plane lines are usually labeled with a letter at either end to identify the drawing of the cut surface indicated by the same letters on the same sheet of paper. The cut surface drawing is called a section.

FIGURE 1-14
Cutting Plane Lines



Sectional View A-A

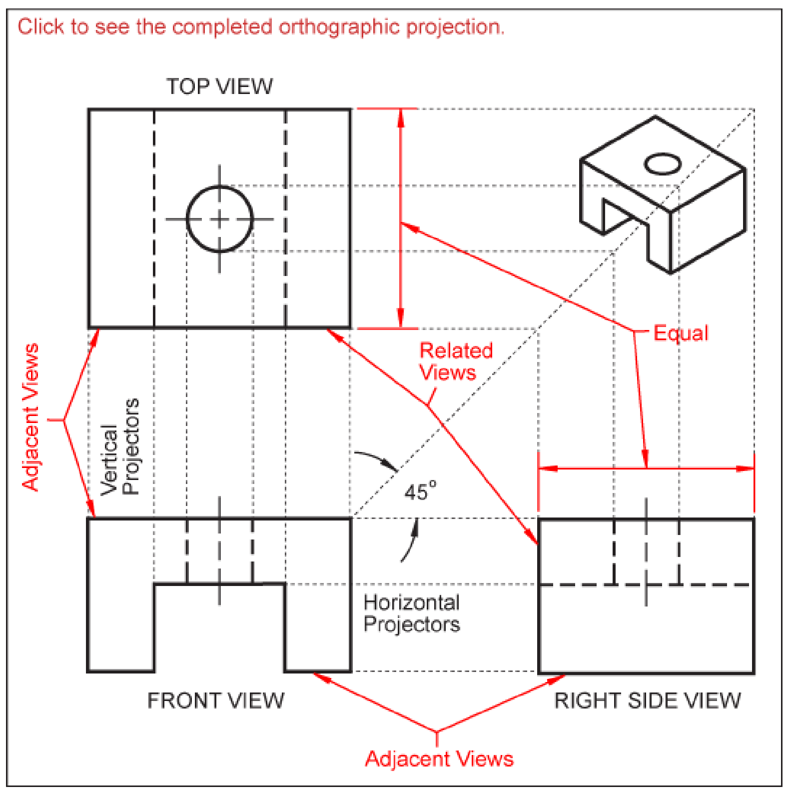
Remember, the two factors which determine the appearance of a line are its relative thickness and its composition. **Lines are drawn in two thicknesses—thick and thin**. The composition of a given type line refers to the factors such as whether it is solid or broken, whether it contains dashes, whether the dashes are short or long or alternating, and similar variations in the way the line is drawn. Application of lines is vital to ensure that the placement of the line does not interfere with the accurate representation of the part or subject of the drawing. For example, a hidden line begins with a dash in contact with the line from which it starts except when a dash would form a continuation of a solid line.

Multiview Orthographic Projections

Orthographic projection is a projection of a single view of an object on a drawing surface that is perpendicular to both the view and the lines of projection. Horizontal orthographic projection lines are used to align views with the same height dimensions. Vertical orthographic projection lines are used to align views with the same width dimensions (Fig. 8- 1). The technique of orthographic projection is used to create multiview drawings of a single object. The related views of the object appear as if they were all in the same plane. Multiview drawings describe the exact size and shape of an object. Figure 8-2 shows a CAD-generated multiview drawing of a machine part.

The following steps take you through the creation of an orthographic projection.

1. Choose a front view. This is the view that shows the most about the object.
2. Decide how many views are needed to completely describe the object. If you are unable to determine which views will be needed, draw the standard views (front, top and right side).
3. Draw the visible features of the front view.
4. Draw projectors off of the front view horizontally and vertically in order to create the boundaries for the top and right side views.
5. Draw the top view. Use the vertical projectors to fill in the visible and hidden features.
6. Project from the top view back to the front view. Use the vertical projectors to fill in any missing visible or hidden features in the front view.
7. Draw a 45° projector off of the upper right corner of the box that encloses the front view.
8. From the top view, draw projectors over to the 45° line and down in order to create the boundaries of the right side view.
9. Draw the right side view.
10. Project back to the top and front view from the right side view as needed.
11. Draw center lines where necessary.



Describing the shape of an object with a multiview drawing should always be accomplished with the minimum number of views. **The first view chosen is the front view because it best shows the**

form of an object.

Other objects may require up to six views to show the exact Size and shape of each side (Fig. 8-10). Figure 8-11 shows a six-view drawing of the same clock radio shown in the three views of Figures 8-6 through 8-8.

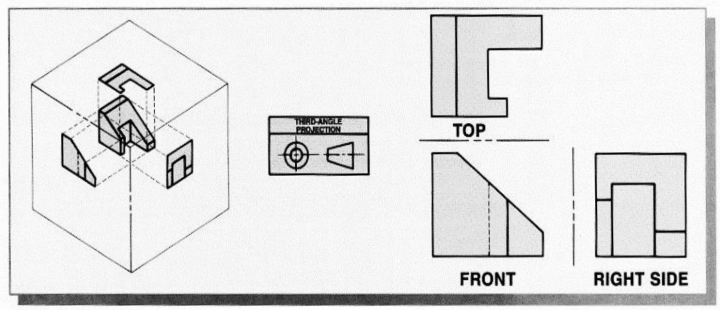


Figure 8-17
Third-angle projection

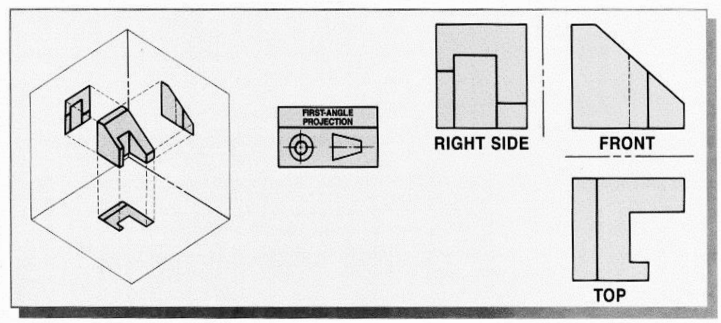


Figure 8-18
First-angle projection

Angles of Projection

The three basic views used in multiview drawings in the United States are the **front view, right-side view, and top view**. This is known as third—angle projection (Fig. 8-17). In Europe, the three basic views are the front view, left-side view, and bottom view. This is known as first—angle projection (Fig. 8-18). Figure 8-19 shows a comparison of a multiview drawing of the same object using first- angle and third-angle projection.

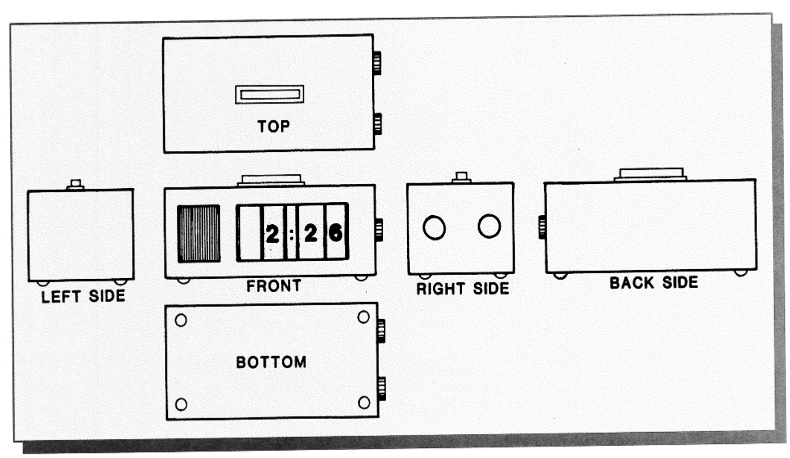


Figure 8-11
A multiview drawing may have a maximum of six orthographic views.

There are six possible views of any object. There is a view for each side or surface of the object: front, back, top, bottom, left side and right side. The development of a multi-view drawing requires the selection and arrangement of some or all of these views. How many and which of these views are selected depends on the nature, shape and complexity of the object being drawn. The only difference between what is called a third-angle and first-angle projection is in the arrangement of the views. International projection symbols, shown in Figure 1-32, have been developed to distinguish between first-angle and third-angle projections on drawings. In the United States and Canada, third-angle projection is standard, while in most of the rest of the world, first-angle projection is used.

FIGURE 1-32
First-Angle Projection

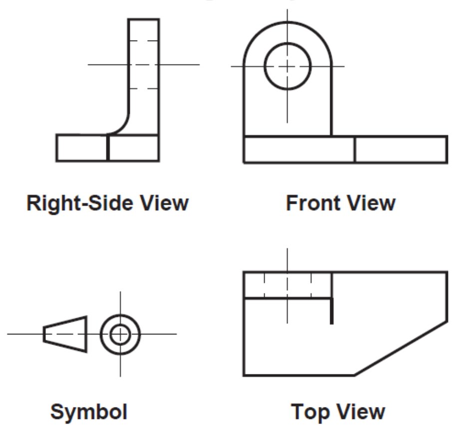


FIGURE 1-33
Third-Angle Projection

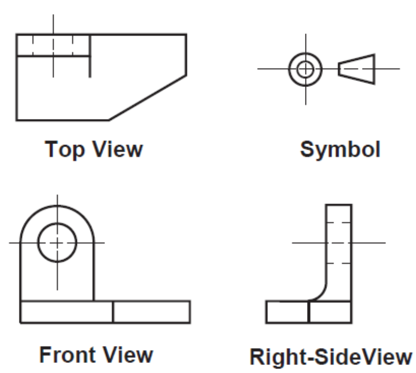
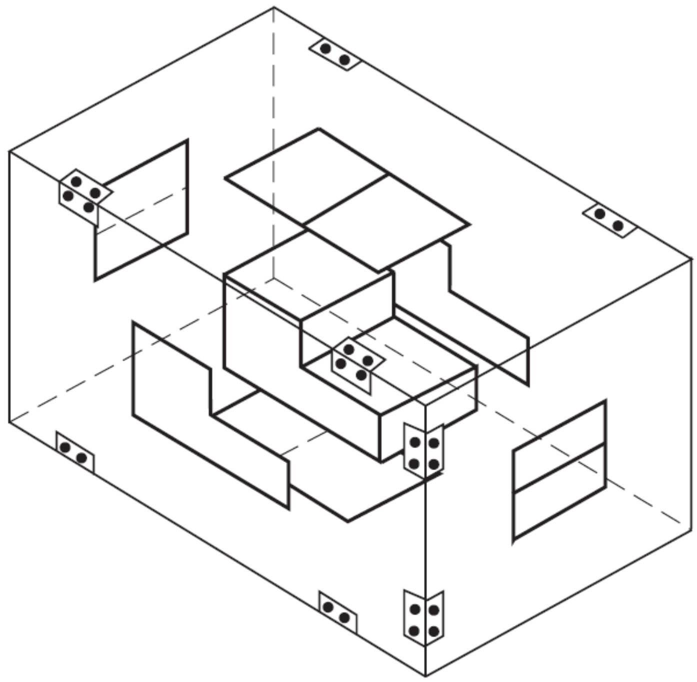


Figure 1-34 is an example of a third-angle projection of a part in a glass box. Each of the six sides of the object is projected onto the sides of the glass box.

FIGURE 1-34
Third-Angle Projection of Part in Glass Box



The glass box is outfitted with hinges so that the sides can be rotated out allowing the box to be viewed as a flat object in a single plane as if the six sides were drawn on a sheet of drawing paper (Figure 1-35).

The sides are arranged as follows:

• The top view aligns directly over the front view.

• The right side view appears directly to the right of and in line with the front view.

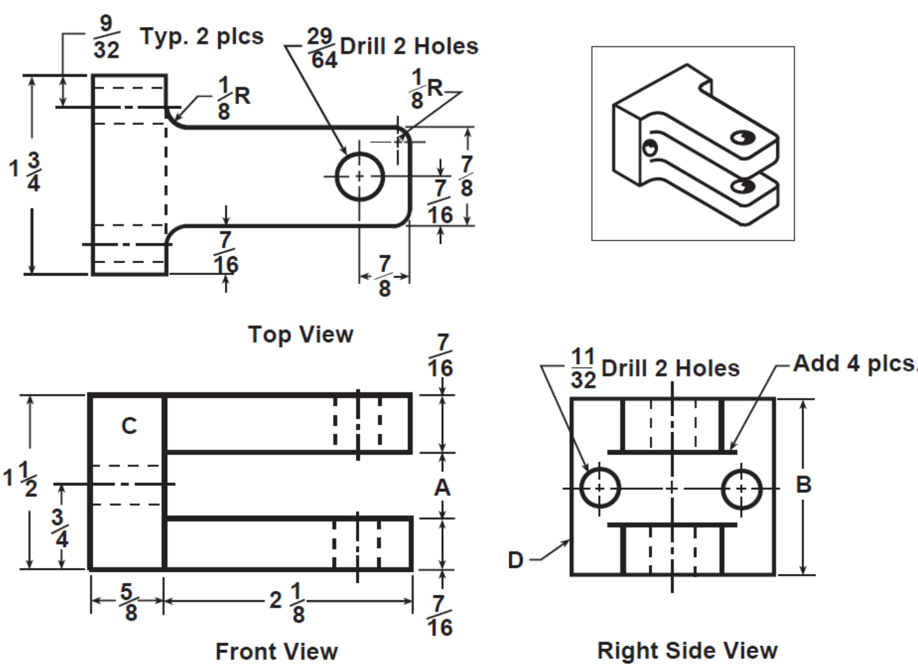
• The left side view appears directly to the left of and in line with the front view.

• The bottom view aligns vertically below the front and top views.

• The back view appears to the left of and in line with the right side, front, and left side views.

It is rare that all six views are required, however, no view should appear in any other position on a drawing. The side views are always placed laterally (to the sides) of the front view in logical sequence. Top views are always above the front, and bottom views are always below the front. It would be possible for the arrangement of views to be different than in Figure 1-35. This would be the result of selecting a different side of the object as the front view. The front view is also referred to as the primary view because the arrangement of all other views is determined by the position of the front view. The side which offers the most detail or clearest view of the object and which results in the least amount of hidden lines is usually selected for the front view. Multi-view drawings are also referred to as detail drawings. The detail drawing in Figure 1-36 was developed from the isometric or pictorial drawing of the object (shown in the top, right-hand corner). The side selected for the front view provides the clearest representation of the object. The top view and right side view have been drawn in positions based on the selection of the primary view.

FIGURE 1-36
Detail Drawing

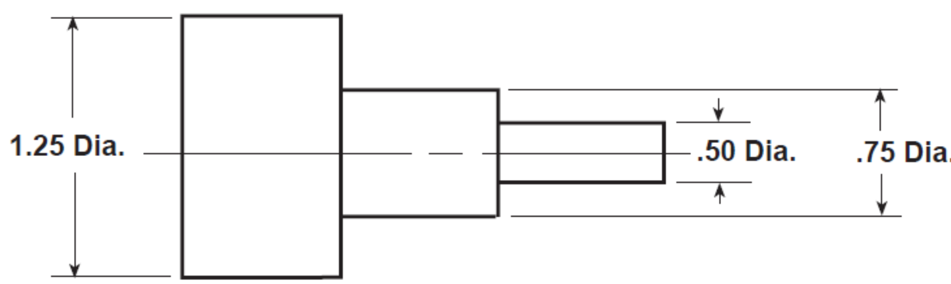


Sometimes it will not be necessary to show all three basic views of an object in order to depict all the necessary information required for its manufacture. A ball bearing would appear the same regardless of the angle of the view. A single view would be sufficient to show the size and the spherical shape could be explained in a note. Cylindrical objects and parts which are flat and thin may also be represented using one view (see Figure 1-37). A front view is selected that provides the best visualization of the size and shape of the object.

FIGURE 1-37
Cylindrical Object

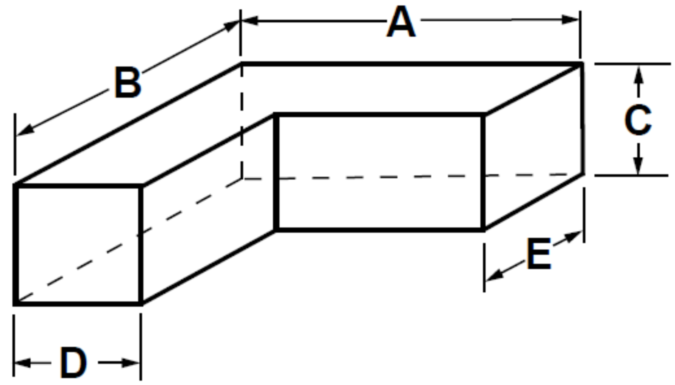
Cylindrical objects require a center-line running through the middle of the piece and the letter D for diameter, in the dimensions. Although there are three different diameter shafts in Figure 1-38, the addition of the three dimensions to the front view eliminates the need for the side view. Any extra machining operations to be done on the part such as drilled holes, threads, keyways, counter-bores and countersinks would require a second or even a third view to accurately describe their size and location.

FIGURE 1-38
Cylindrical Object



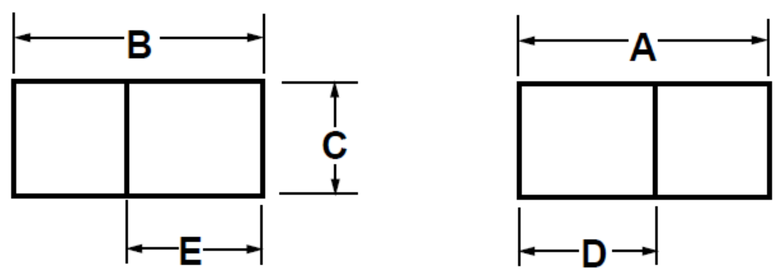
In most cases, at least two views are necessary to represent a single part. Choose the view with the least hidden lines as the primary or front view. For example, several different views could be selected for the part shown in Figure 1-39.

FIGURE 1-39
Different Views



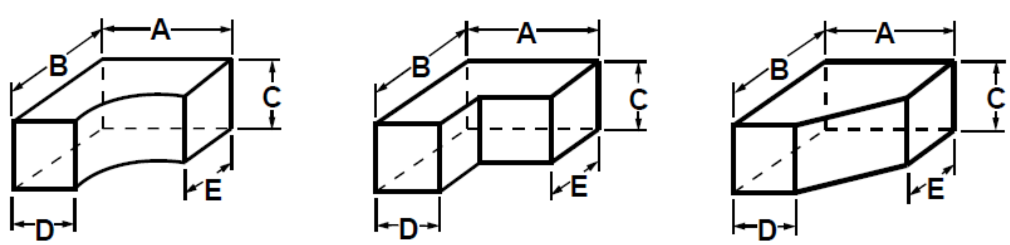
If the primary or front view is used and front and side views are selected as the two views for the multi-view drawing, the object is not truly defined (see Figure 1-40).

FIGURE 1-40
Different Views



Using these two views, the slot can be several different shapes, but still correspond to the front and side views selected in the initial multi-view (see Figure 1-41).

FIGURE 1-41
Different Views



If the side view is replaced by the top view, only one of these three possibilities is accurate. Therefore, the correct two-view drawing of the object must include the front and top views (Figure 1-42). The side view could replace the front view although this is not a common drafting practice.

In the fields of engineering and architecture, there are three basic types of pictorial drawings: **axonometric, oblique, and perspective**.

Axonometric drawings are most frequently used for engineering drawings. **Oblique** drawings are used mostly for simple thin objects or for progressive design sketches. **Perspective** drawings are used extensively to create realistic renderings of objects such as buildings, cars, and boats.

2D and 3D Drawing Development on a 2D Surface

To satisfy requirements for preparing single or multi-view drawings, there are two main types of projection: parallel and perspective **(Figure 6-1)**. Parallel projection is further classified into subtypes according to the direction of its projection lines relative to the plane of projection. If the projection lines are not only parallel to each other but are also perpendicular (normal) to the plane of projection, the result is an orthographic projection. If they are parallel to each other but oblique to the plane of projection, the result is an oblique projection.

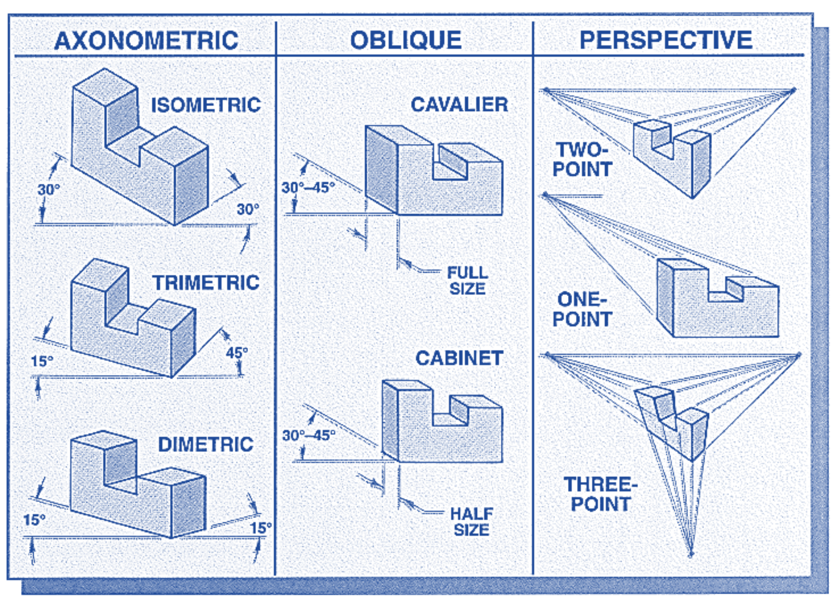


Figure 15-5a
Various types of pictorial drawings

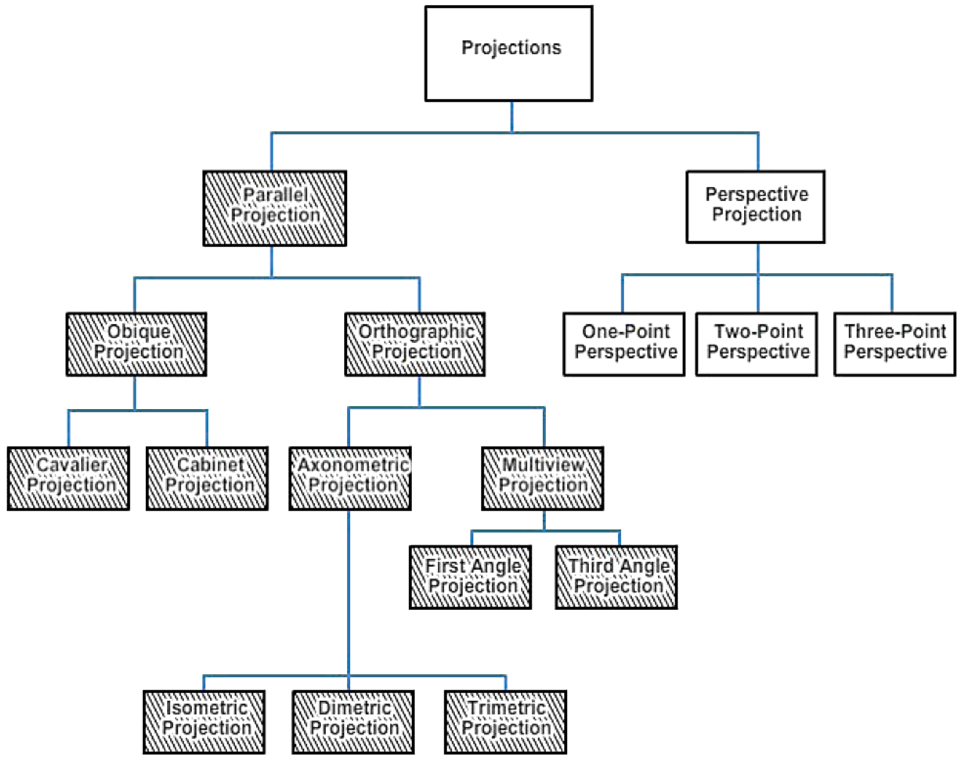


Figure 6-1 – Classification of major projections.

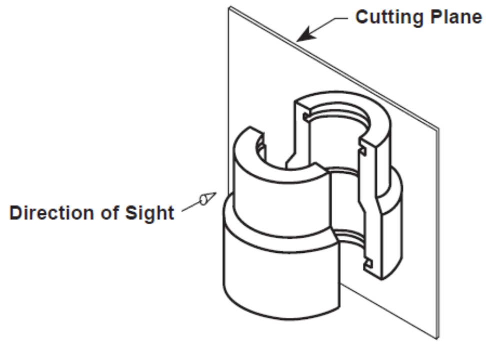
Sectional and Auxiliary Views

Objects that are complex in shape, or that have many interior features, can be difficult and confusing to depict in multi-view projections. Two special techniques used to provide a clearer representation of how such an object should be constructed are sectional views and auxiliary views.

1. Sectional Views

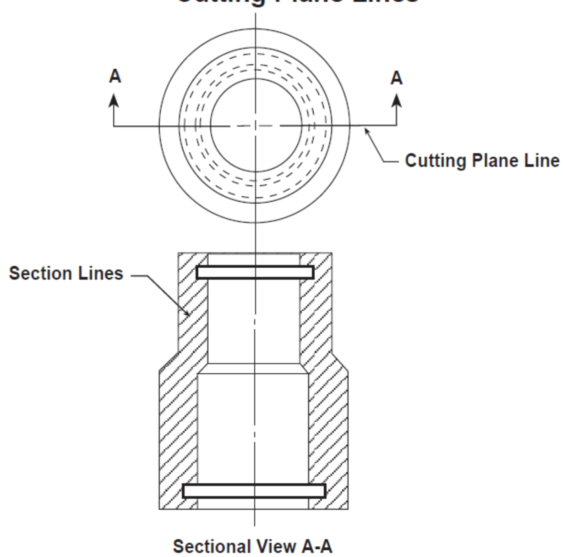
Sectional views, or just sections, are used to show interior detail that is too complicated to be shown clearly by outside views and by the use of hidden lines. In assembly drawings, they also serve to indicate a difference in materials. A sectional view is obtained by imagining that a portion of the object has been cut away to expose internal lines and surfaces **(Figure 1-43)**. The exposed or cut surfaces are identified by section lining or crosshatching. A sectional view frequently replaces one of the regular views.

FIGURE 1-43
Sectional View



A cutting plane line is used to indicate where the imaginary cutting takes place. The position of the cutting plane is indicated, when necessary, on a view of the object or assembly by a cutting plane line. The ends of the cutting plane line are bent at 90° and terminated by arrowheads to indicate the direction of site for viewing the section **(Figure 1-44)**.

FIGURE 1-44
Cutting Plane Lines

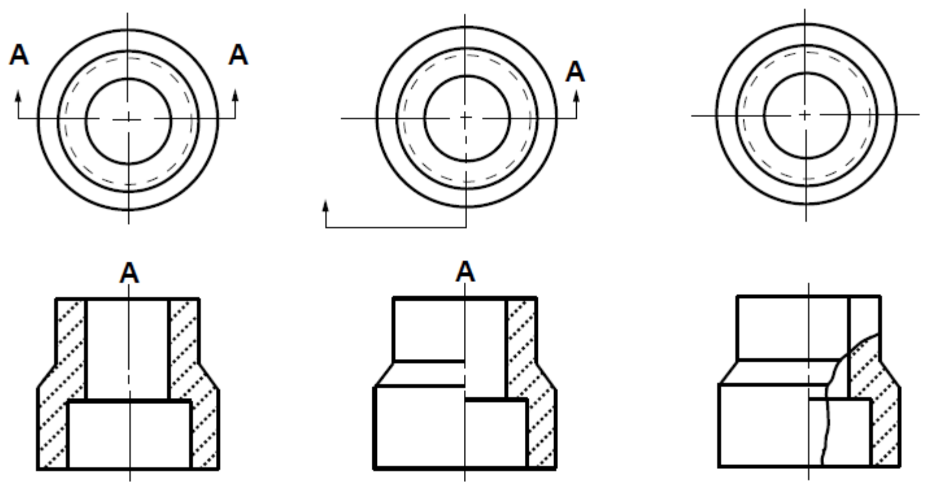


Full sectional views are obtained by passing the cutting plane across the entire object, exposing the whole inner surface. Half-sectional views are obtained by placing two cutting planes at right angles to each other along the center-lines or symmetrical axes of the object, exposing one-half of the inner surface. The cut is made along the horizontal and vertical center-lines so that either one-fourth or three-fourths of the interior of the object is exposed.

A broken-out or partial section is sometimes necessary to show a single detail, or a closely related group of details, that exist within the interior of an object. If these details are all that are needed, then the broken-out partial section view can provide the necessary detail.

Examples of full, half and partial sectional views are shown in Figure 1-45.

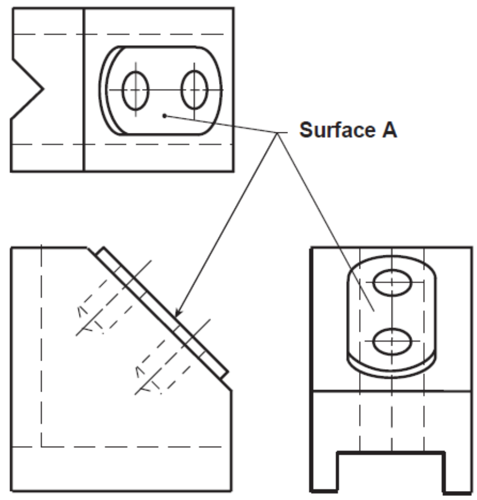
FIGURE 1-45
Multiple Views



2. Auxiliary Views

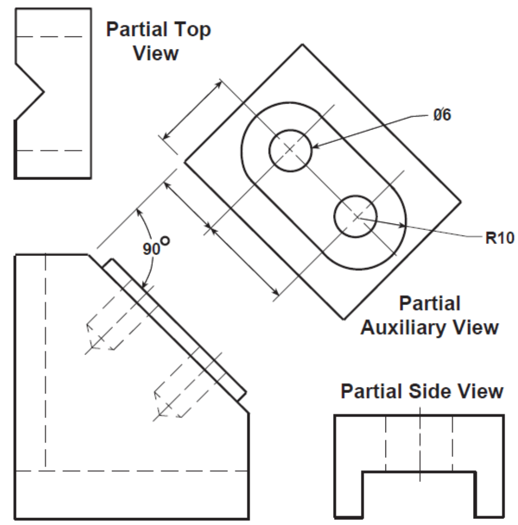
Many machine parts have surfaces that are not perpendicular or at right angles to the plane of projection. These surfaces are referred to as sloping or inclining surfaces. In the regular multi-view projection (see Figure 6-46) such surfaces appear to be foreshortened and their true shape is not shown.

FIGURE 1-46
Regular Views Do Not Show True Features of Surface A



When an inclined surface has important characteristics that should be shown very clearly and without distortion, an auxiliary view is used so the drawing explains the shape of the object completely and clearly. In Figure 1-47, the circular features on the sloped surface on the front view cannot be seen in their true shape on either the top or side views. The auxiliary view is the only view which shows the true shape of these features. Note that only the sloped surface details are shown. Dimensions for the detail on the inclined face are placed on the auxiliary view, where such a detail is seen in its true shape.

FIGURE 1-47
Auxiliary View Added to Show True Features of Surface A



3. Multi-View Review

In blueprint reading, the term projection refers to a view of an object. Multi-view or three-view projections are drawings that illustrate a combination of views of an object. The primary view or front view determines the arrangement of all other views on the drawing. There is a possibility of at least six views of an object plus the additional potential for auxiliary and section views. The top, bottom, left and right sides, and back views are developed by projecting lines at a 90° angle, horizontally and vertically, from the front view. In arranging views, the side views are always placed laterally (to the sides) of the front view in logical sequence, the top view is always above the front, and the bottom view is always below the front.

Conventions for dimensioning are covered in Chapter 9. Some consideration of dimensioning needs is necessary, however, when planmng and preparing multiview Use the following guidelines in planning for the dimensioning of multiview drawings :

Spacing between views depends on the number of dimensions to be placed between the views (Fig. 8-31)

Place the closest dimension to the view at .5" clearance. Every additional dimension is spaced .375" apart (Fig.8-32) Place as many dimensions as possible between views (Fig. 8-33), rather than on the outside.

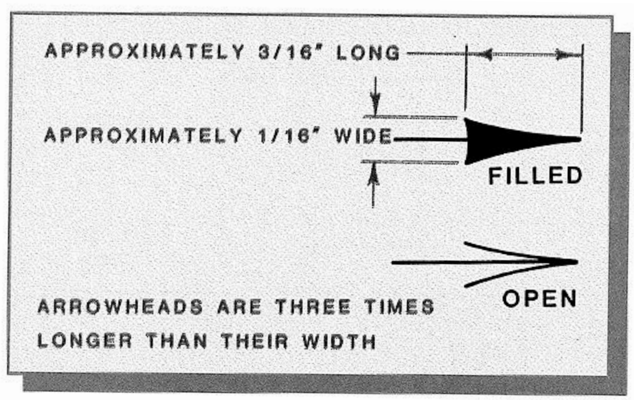


Figure 9-13
The freehand arrowhead and its proportions

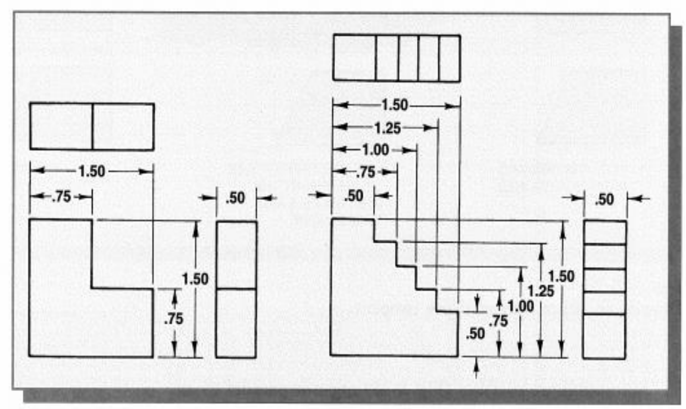


Figure 8-31
The numbers of dimensions between views will determine the space between the views

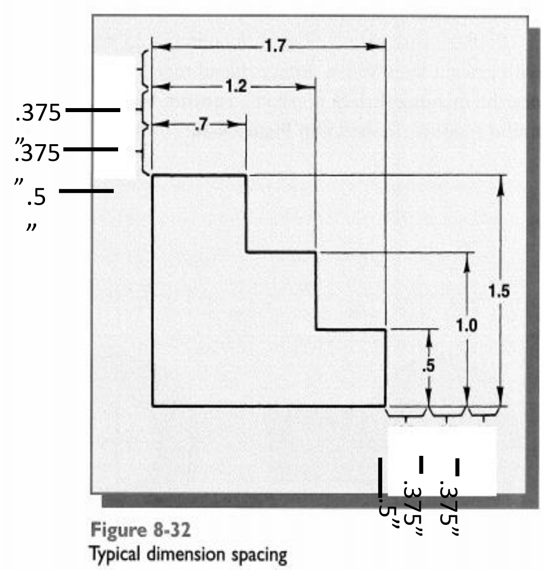


Figure 8-32
Typical dimension spacing

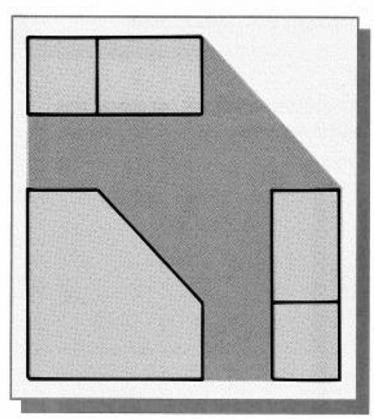
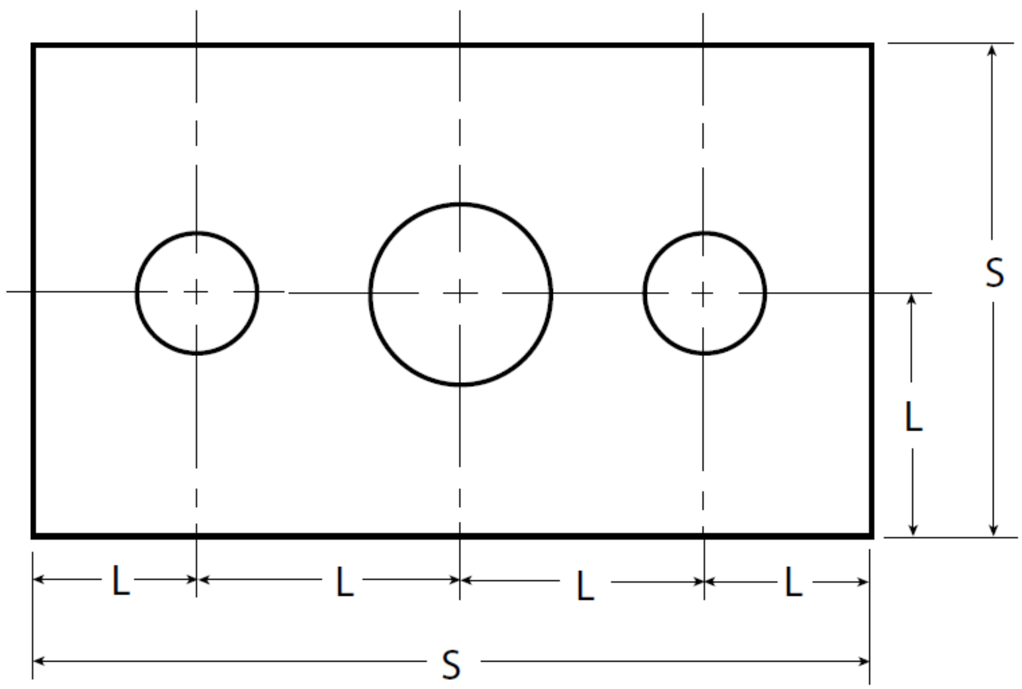


Figure 8-33
Place as many dimensions as possible between the views.

Dimension Types

Dimensions enable the designer of a product to express exact linear and angular distances. There are two types of dimensions used in plan reading and drafting: size and location. The first type is used to indicate the exact size of the product. The second gives exact locations of the holes, indentations, etc. on an object. Examples of both types of dimensions are shown in Figure 1-29.

FIGURE 1-29
Dimension Types

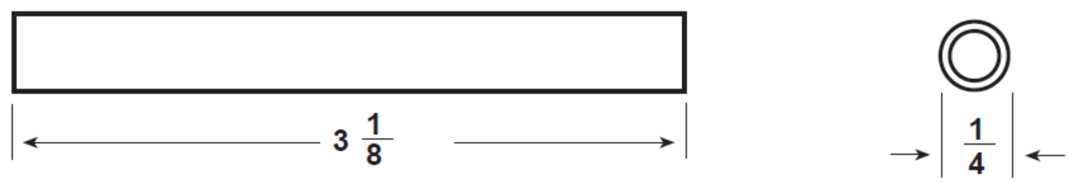


S = Size Dimensions
L = Location Dimensions

The diameter of a circle would also be considered a size dimension. Dimensions are used to measure straight and angular distances. Straight distances are expressed in fractional or decimal form. Angular measures are expressed in degrees, minutes and seconds.

Fractional dimensions are used on parts which do not require a high degree of accuracy. In most blueprint systems, when an object is fractionally dimensioned it is implied that the overall dimension is to be maintained plus or minus 1⁄64 “. The print in Figure 1-30 calls for a piece of tubing 3 1⁄8” x 1⁄4”. It is implied that the part can be 3 1⁄8” + 1⁄64” or between 3 7⁄64” and 3 9⁄64” in length and be 1⁄4” + 1/64 or between 15⁄64” and 17⁄64” in diameter.

FIGURE 1-30
Fractional Dimensions



Decimal dimensions, on the other hand, are used on parts requiring a high degree of accuracy. Many blueprints use decimal dimensioning entirely, even though the criticality of the dimensions may vary. There is usually a note on the print stating the tolerance for the less critical dimensions.

Sectional views reveal an object’s inner detail by graphically removing portions of the surface. This is done in a standardized way by using a cutting plane line or break lines. Either way, the purpose of sectional views is to simplify the drawing by eliminating hidden lines. Auxiliary views show an inclined surface or line in its true size and shape. This makes it easier to visualize the object and provides a true surface to be dimensioned according to standard drawing practices.

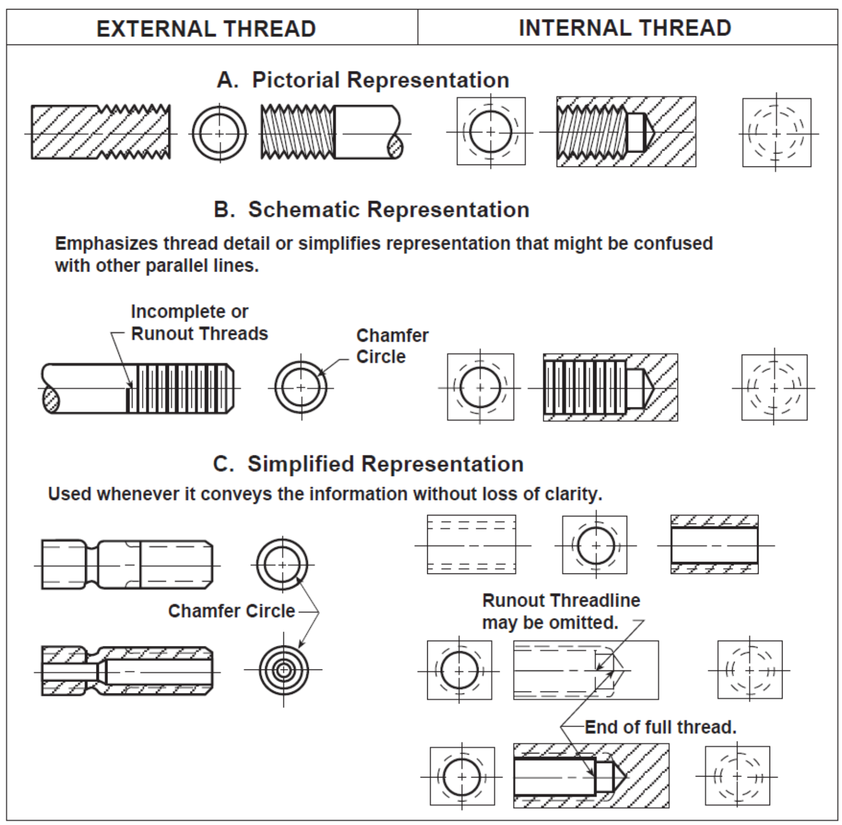
SYMBOLS AND TERMINOLOGY

In addition to lines, information on plan reading and drafting is often provided by a variety of standard symbols and terminology. These terms and symbols eliminate the need for drawing each item in painstaking detail.

Thread Representation

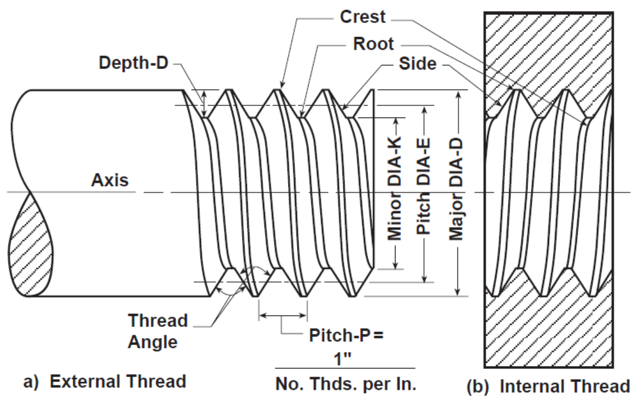
True representation of a screw thread is seldom provided on working drawings because of the time required to draw such detail. Three types of conventions, or accepted drafting practices, are in general use for screw thread representation: pictorial, schematic and simplified presentation. Simplified presentation is used to clearly portray the requirements. Schematic and pictorial representations require more drafting time but they are sometimes used to avoid confusion with other parallel lines, or to more clearly portray particular aspects of threads. The three types of thread representations for internal and external threads are shown in Figure 1-15.

FIGURE 1-15
Three Types of Thread Representations



Threaded fasteners are used throughout industry, so it is important that you are familiar with the descriptive terms used to identify specific thread arrangements. Figure 1-16 shows the terms used in describing a threaded part.

FIGURE 1-16
Threaded Part



For convenience, several series of diameter-pitch combinations have been standardized. These series are Coarse, Fine, Extra Fine, and the Unified pitch series; that is, 8 thread, 12 thread, and 16 thread. The fit of a screw thread is the amount of clearance between the screw and the nut when they are assembled together. To provide for various grades of fit, three classes of external threads (Classes 1A, 2A, and 3A) and three classes of internal threads (Classes 10, 2B, and 30) are provided in the unified thread standard. These classes differ from each other in the amount of allowances and tolerances.

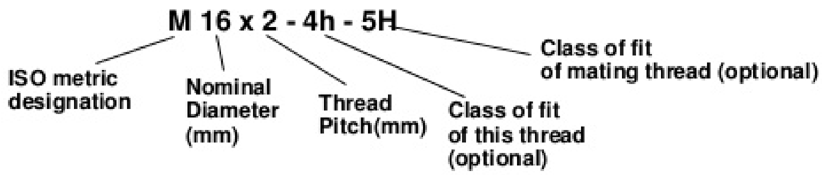
A number of different specifications are given in representing screw threads on a drawing:

- Diameter of the thread
- Number of threads per inch
- Thread series either National Coarse, National Fine, National Extra Fine, Square, Acme or Pipe
- Class of fit, ranging from a loose fit No. 1 to the theoretically most perfect fit attainable

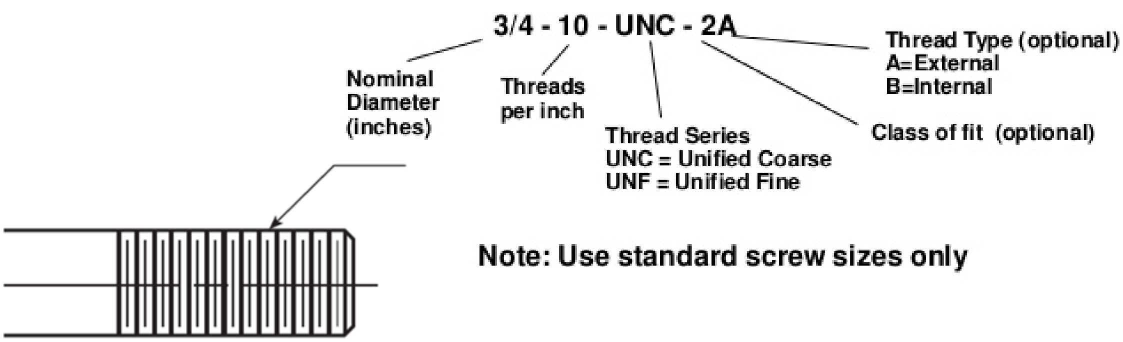
These specifications are usually presented in notation like those in Figure 1-17.

Screw Threads

ISO specify metric only:M 16 x 2

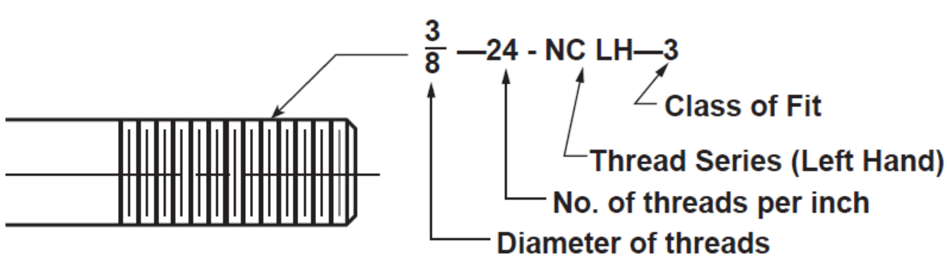


American Unified Threads: 3/4 - 10 - UNC



Unless designated otherwise, threads are assumed to be right handed. A cap screw being threaded into a tapped hole would be turned in a right-hand clockwise direction. For some special applications, such as turnbuckles, left-hand threads are required. When such a thread is necessary, the letters LH are added after the thread designation (see Figure 1-18).

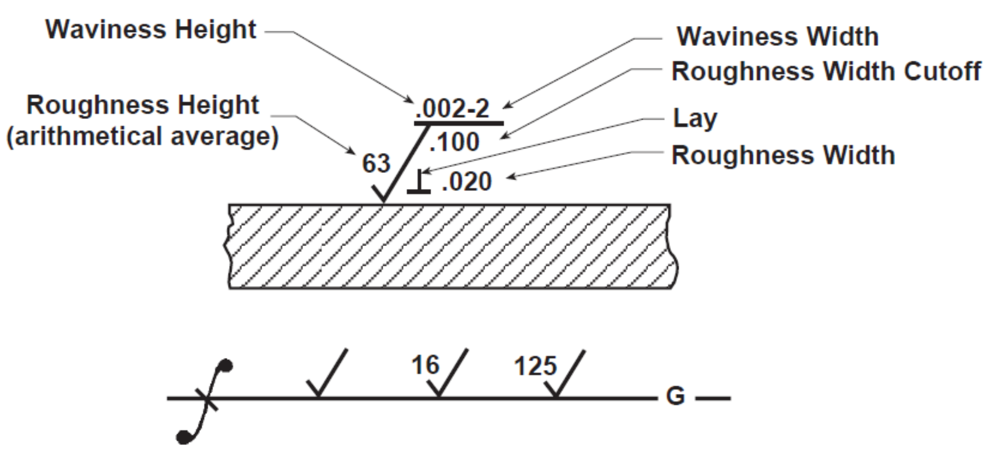
FIGURE 1-18
Left-Hand Thread Notations



Finish Symbols

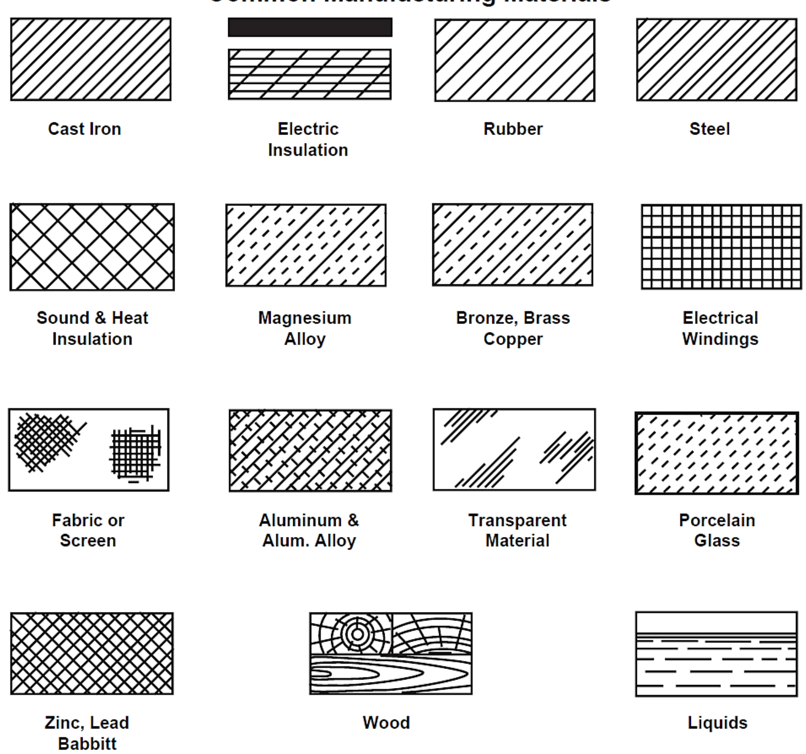
The term finished surface means any surface that requires material to be removed from it in order to improve its size, geometry or smoothness. This can be done by such processes as planing, milling, turning, broaching or grinding. The method used depends on the contour, the type of finish required and the kind of material. A surface finish symbol is used to indicate that a specific surface finish is required. Numbers are added to the left of this basic symbol to designate surface roughness in micro-inches or millionths of an inch (arithmetical average deviations from the center line of the surface as measured by a profilometer or surface analyzer). Numbers may also be written above the horizontal extension of the symbol to designate maximum waviness height, in decimal inches, and maximum waviness width, in inches, placing the width notation to the right of the maximum height notation. The symbols used to indicate surface finish are shown in Figure 1-19 along with standardized finishes in micro-inches.

FIGURE 1-19
Finish Symbols



Micro inches	Type of Surface	Purpose
1000	Extremely Rough	Clearance surfaces where appearance is not important
500	Rough	Used where stress requirements and close tolerances are not required.
250	Medium	Most popular where stress and tolerances requirements are essential.
125	Average Smooth	Suitable for mating surfaces and parts held by bolts and rivets with no motion between them.
63	Better than Average Finish	For close fits or stress parts, except rotating shaft, axles and parts subject to extreme vibration.
32	Fine Finish	Used where stress concentration is high, and for applications such as bearings.
16	Very Fine Finish	Used where smoothness is of primary importance, i.e. high-speed shaft bearings, heavily- loaded bearings and extreme tension members.
8	Extremely Fine Finish (by grinding, honing, lapping and buffing)	Used for cylindrical surfaces.

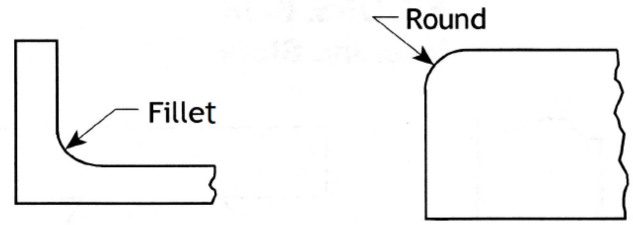
FIGURE 1-13
Common Manufacturing Materials



Fillets and Rounds

Fillets and rounds (see Figure 1-20) are designed into parts for purposes that include strengthening a shoulder on a shaft, enhancing the appearance of a corner, or removing the sharp edge on a part.

FIGURE 1-20
Fillets and Rounds

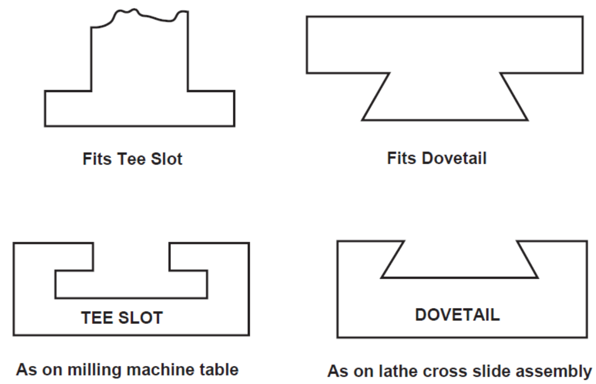


A fillet is made by allowing for additional metal in the inner intersection of two surfaces. The rounding out of the internal corner increases the strength of the object. A round or radius is made by rounding off the external edge of a sharp corner on an object. This rounding off improves appearance and allows for avoiding the forming of a sharp edge that could cause interference or chip off under a sharp blow.

Machine Slots

Parts made on lathes, mills and other machine tools must be held in place while being machined. Slots are used as a means to secure parts or hold parts together.
Two of the main types of slots are tee slots and dovetails (see Figure 1-21).

FIGURE 1-21
Machine Slots



The use of plan reading and drafting is most commonly associated with machine shop operations. However, plan reading and drafting in the form of schematics, sketches,

FIGURE 1-22
Terms

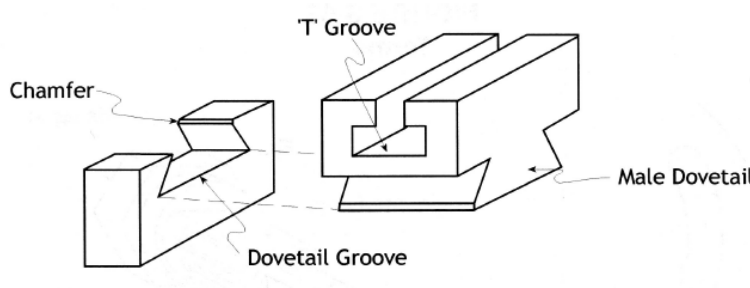


FIGURE 1-23
Terms

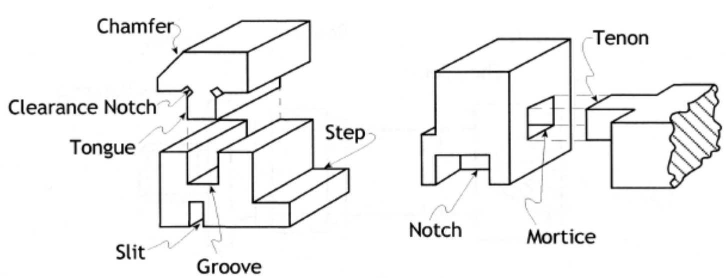
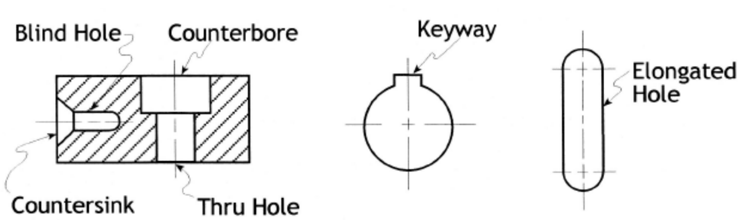


FIGURE 1-24
Terms



diagrams and pictorial representations also are used in manufacturing, maintenance and construction. Figures 1-22 through 6-26 show an assortment of terms used with plan reading and drafting. The glossary further defines these and other relevant terms.

FIGURE 1-25
Terms

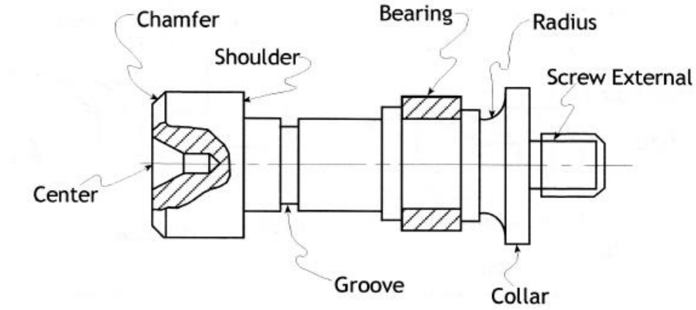
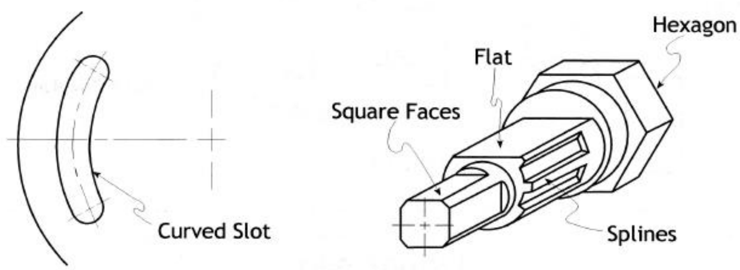


FIGURE 1-26
Terms



Title Blocks

The title block, usually located in the lower right-hand corner of a drawing, contains information that is not always directly related to the construction of an object, but is needed for its manufacture. The title block's location, content, layout, and appearance will vary from company to company, but will usually be standardized within a given company. Remember that the purpose of a print is to relay information in a simple, accurate graphic language. The title block allows the draftsman or engineer to include important information without lettering up the drawing. Specific types of information can be included on the print in the title block so that it can be located easily and interpreted correctly. In addition to the title block, notes and revisions can also be included on a print to further clarify the information contained in the drawing. The title block is divided into sections which may provide the following information:

• **Company** name and location.

• **Part** name.

• **Part number**, die number, forging number, etc.

• **Drawing number** assigned to the part number.

• **Number of parts** required for each assembly.

• **Scale** indicates the size of the drawing compared with the actual size of the part. Detail drawings are usually made full size. Large parts and assemblies may be drawn to a reduced scale to fit on the paper. Very small parts may be drawn two or three times their actual size to show details clearly. The most common scales are full (actual) size, and 2, 4, 1⁄2, and 1⁄4 times the actual size.

• **Assembly drawing number** (on a detail drawing) to identify the part in the assembly.

• **Drafting room record** includes names or initials (with date signed) of persons responsible for the accuracy of the drawing, draftsman, checker, engineer, and examiner and production approval authority.

• **Material callouts** or materials to be used in making the part, with optional materials. Reference is usually made to notes due to limited space in the block.

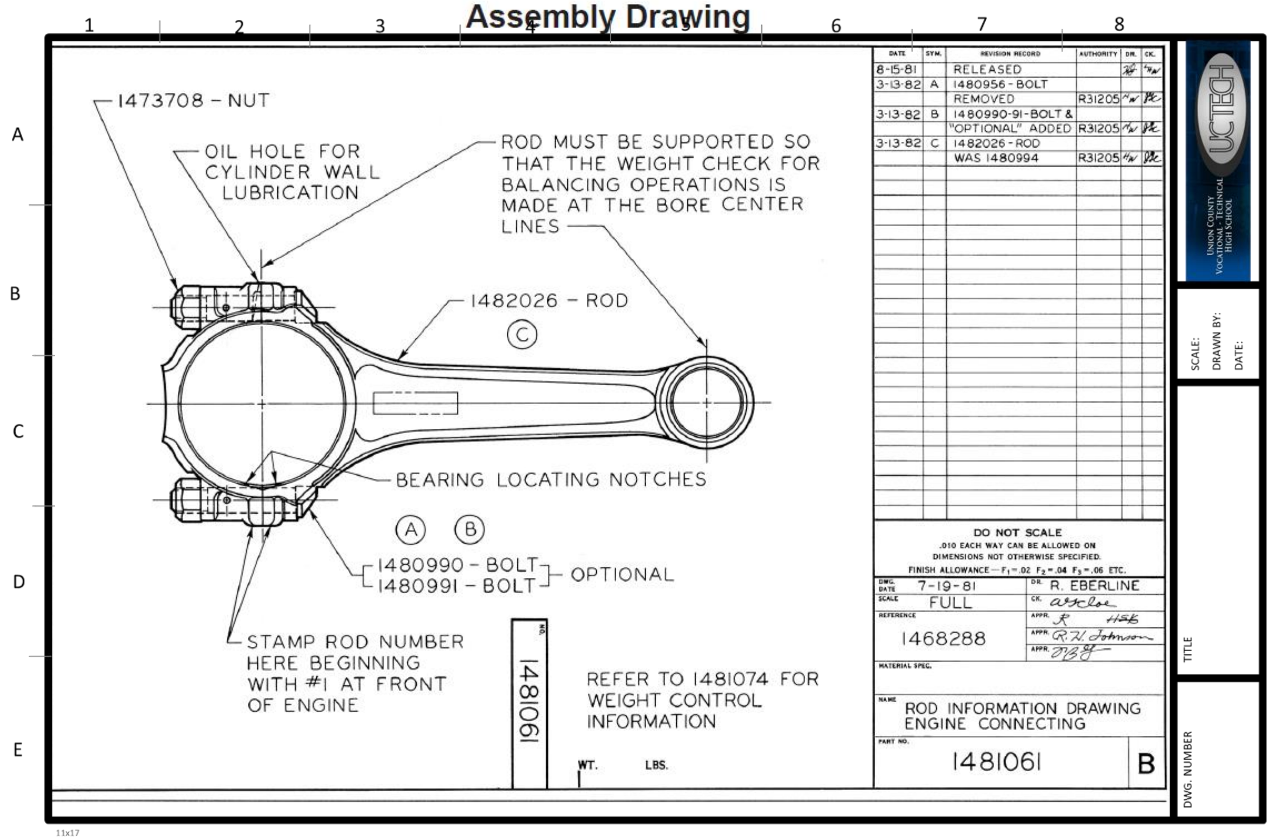
• **Stock form** and/or size.

• **Tolerances** (general) that apply to all dimensions that do not have individual tolerances included with the basic dimensions.

• **Drawing revisions** or changes call attention to variations in original design caused by unsatisfactory performance or difficulty in manufacturing. Changes are usually located in upper, right-hand corner of a drawing in a separate box called the Revision Box. All changes to the drawing are entered, dated and identified by a number or letter, and a letter indicating that it is a revised drawing is added to original drawing number.

Figure 1-27 is an assembly drawing of a connecting rod. The title block includes the part name and number; information about the scale, tolerances, and finish allowances; the date of the drawer, checker and approvers; the print's reference number; and a space for the material specification. In addition, there is a revision record and notes on the drawing concerning parts and assembly techniques.

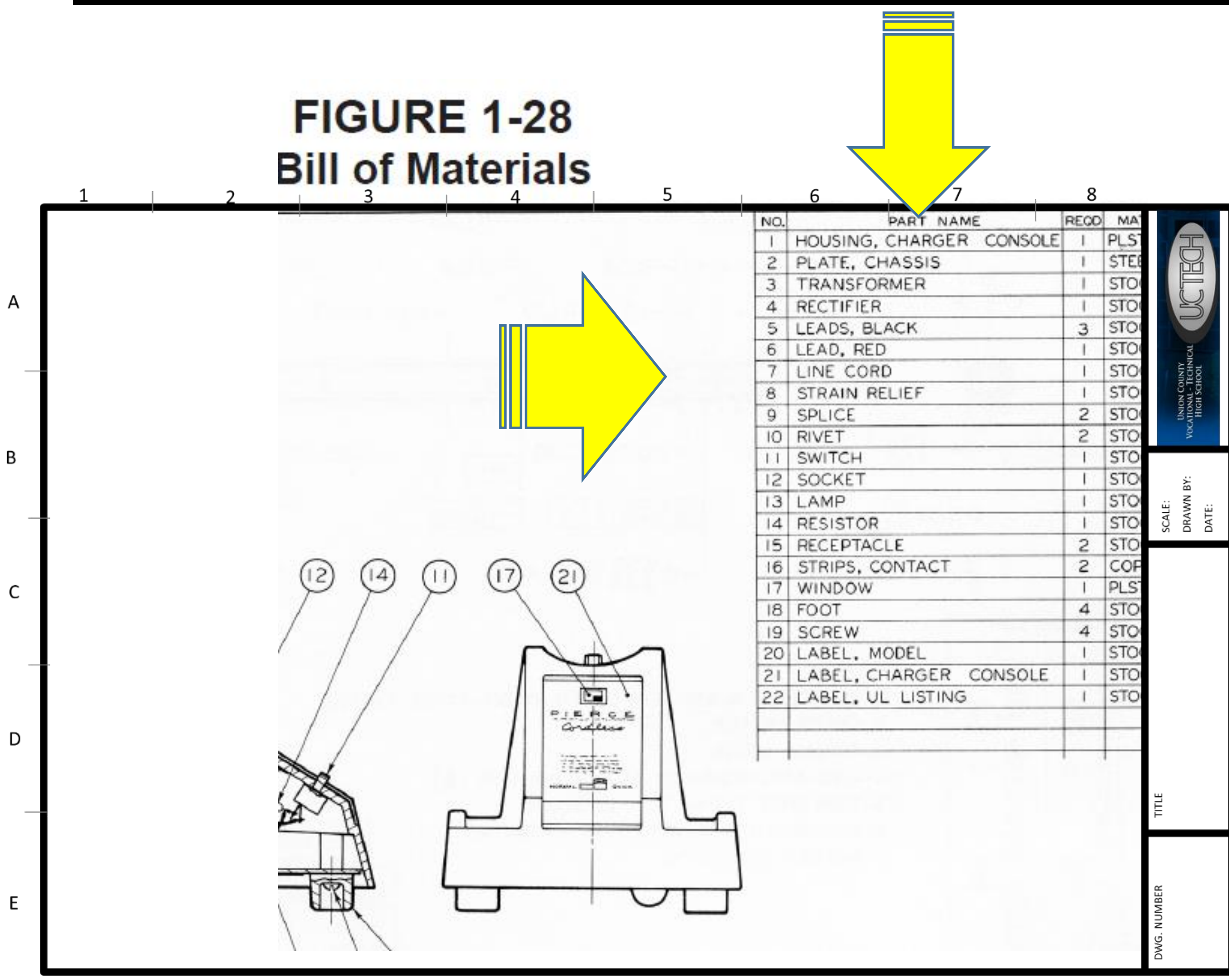
FIGURE 1-27
Assembly Drawing



The drawing in Figure 1-28 has a title block that includes notes (notice that the drawing has been redrawn and also that the UL label is new). This drawing also includes a bill of materials which identifies the parts by name, the required number of each part, and the material callout for each part. A bill of material may also include part numbers, dimensions and other relevant information.

NO.	PART NAME	REQUIRED	MATERIAL

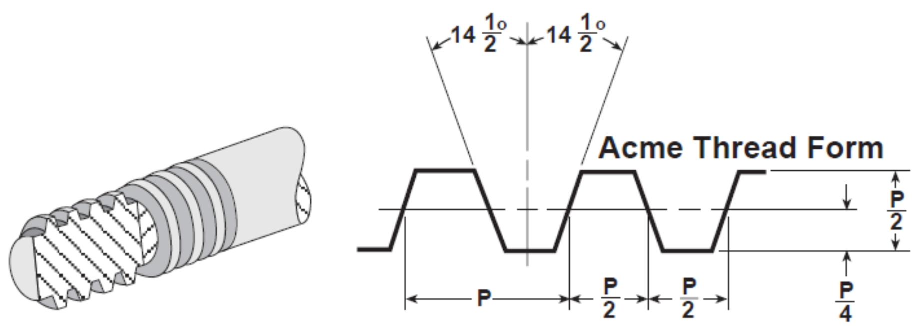
FIGURE 1-28
Bill of Materials



ABS-ABS stands for acrylonitrile butadiene styrene copolymer, and is a synthetic terpolymer.

Acme – A screw thread form. (See Figure 1-48)

FIGURE 1-48
Acme Screw Thread



Adjacent (Adj.) – Next to; angle that shares a common side of another angle.

Allen Screw – A screw with a hexagonal socket in the head. (See Figure 1-49)

Alloy – Two or more metals in combination.

Aluminum (Alum.) – A lightweight, white, soft, nonferrous metal produced from bauxite ore.

American Iron and Steel Institute (AISI) – A professional organization of engineers responsible for research and standards in the steel and iron industry.

American National Standard Pipe Threads (ANPT) – A 60-thread form cut straight or, more commonly, tapered at 3⁄4 in. 1 ft.. Pipe is used to conduct fluid or gas.

Angle (Ang.) – A geometric figure formed by two lines intersecting, or meeting at a point.

Anneal – To heat and then cool gradually to reduce brittleness and increase ductility.

Architect's scales -Triangular rulers used wherever dimensions are measured in feet and inches; major divisions on the scales represent feet, which in turn are subdivided into 12ths or 16ths, depending on the individual scale.

Assembly (Assy.) – A mechanism consisting of two or more parts placed in proper locations.

AXONOMETRIC PROJECTION—A drawing that shows the inclined position of an object in an isometric, dimetric, or trimetric format.

Auxiliary (Aux.) – An orthographic view not contained in any of the six regular planes of projection, but constructed from one or more of them.

Bevel – An inclined edge, not at a right angle, to an adjoining surface.

Blueprint (B/P or BP) – A photographic copy of an engineering drawing; a graphic communication from a designer or engineer that tells a mechanic how an object looks.

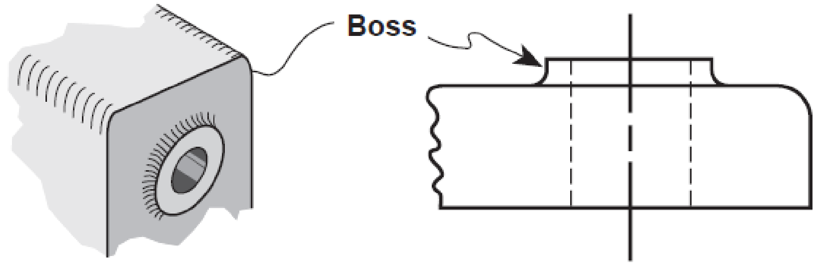
Body – The largest diameter found on a screw. The main portion of any object.

Bolt Circle (BC) – The circular centerline for any group of part features, usually bolt holes.

Bore – The inside diameter of a cylinder. Bore size is usually designated by the length of the diameter.

Boss – A raised, machined surface that adds strength, facilitates assembly, provides for fastening, etc. (see Figure 1-52)

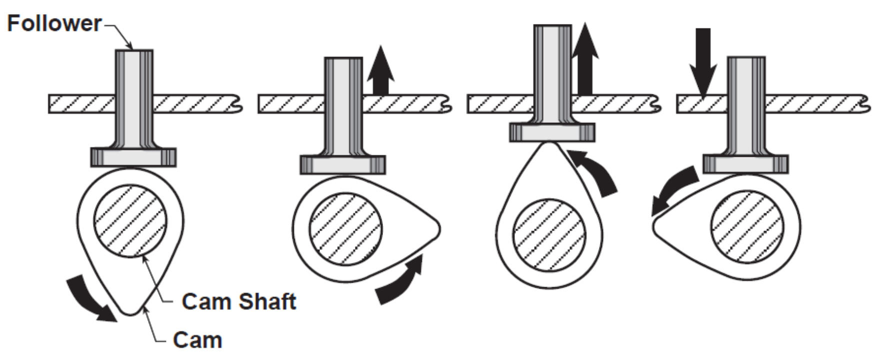
FIGURE 1-52
Boss



Broken-Out-Section – The region of an object graphically removed to show inner detail. Bound by an irregular break line.

Cam – A rotating member for changing circular motion to reciprocating motion. (see Figure 1-53)

FIGURE 1-53
Cam



Casting (Cstg.) – A part produced when molten metal is poured into a preformed cavity, and allowed to solidify before removing.

Cast Iron (CI) – A brittle, ferrous metal alloy containing large quantities of carbon that is cast into a shape.

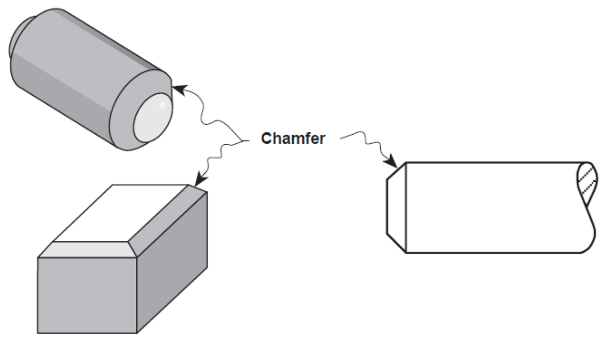
Centerline or Center Line (CL) – The imaginary horizontal or vertical line passing through the center of a part feature, extending infinitely in both directions.

Center-to-Center (C to C) – Any reference to the imaginary line running between and intersecting the centers of two sharp edges.

Chamfer (Cham)

– A bevel or angle cut across the edge of a part to give a finished look or to remove sharp edges. **(see Figure 1-54)**

FIGURE 1-54
Chamfer



Chuck – A mechanism for holding a rotating tool or work piece.

Circumference (Circum.) – The perimeter of a circle. Also, the distance around a circular part. The length of the periphery of a circle or circular part.

Clockwise – Rotation in the same direction as the hands of a clock.

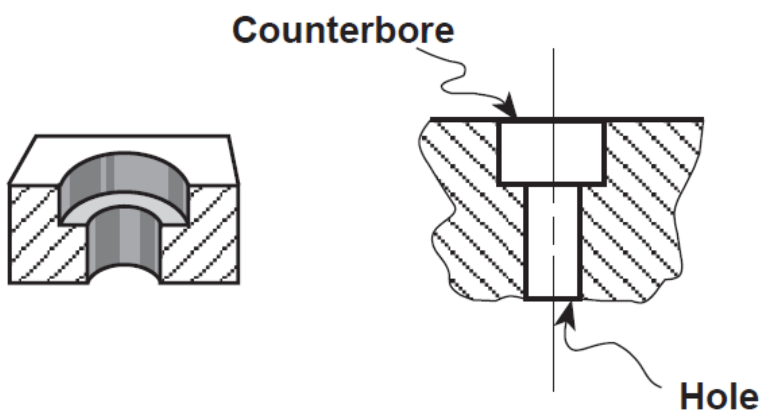
Cold-Rolled Steel (CRS) – Bar stock which has been rolled and shaped at room temperature. Usually has a smoother surface finish and more accurate rough dimensional size (±.002) than hot-rolled steel.

Collar – A round flange or ring fitted on a shaft to prevent sliding.

Concentricity – When the positions of consecutive diameters lie along the same axis of a shaft.

Counter bore (C'Bore) – A flat-bottomed enlargement of the mouth of a cylindrical bore used to set the head of fastener below the surface of the work. Also, to enlarge a bore hole by means of a counter bore. (see Figure 1-55)

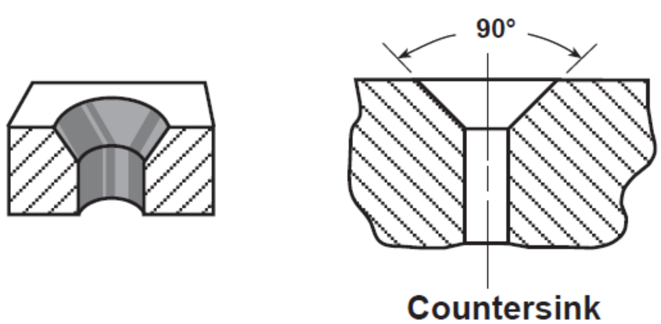
FIGURE 1-55
Counterbore



Counter-Clockwise (CCW) – Rotary motion in the direction opposite that of the hands of a clock.

Countersink (C'Sink) – A bevel or flared depression around edge of a hole used to set the head of a flathead screw below surface of work. (Figure 1-56)

FIGURE 1-56
Countersink



Degree (°or Deg) – Unit of temperature measurement (degrees Fahrenheit or degrees Celsius). Also, unit of angle measurement = 1⁄360 part of a circle.

Detail – Special drawing of an object, or a portion of an object, that requires more information than is normally on a working drawing. The detail may be isolated or enlarged to attract attention to some important aspect or feature.

Diagonal (Dial.) – In a regular square or rectangle, the line drawn between opposite corners: slanting, oblique.

Diameter (Dia or D) – A line segment passing through the center of a circle, and whose end points lie on the circle.

Diametral Pitch (DP) – Ratio of the number of teeth on a gear to the pitch diameter: equals the number of gear teeth per inch of pitch diameter.

Die – One of a pair of hardened metal blocks for forming, impressing, or cutting out a desired shape. Also, a tool sometimes used to cut external screw threads (thread-cutting die).

Die Casting – A very accurate and smooth casting made by pouring a molten alloy (usually under pressure) into a metal mold or die. Distinguished from a casting made in sand.

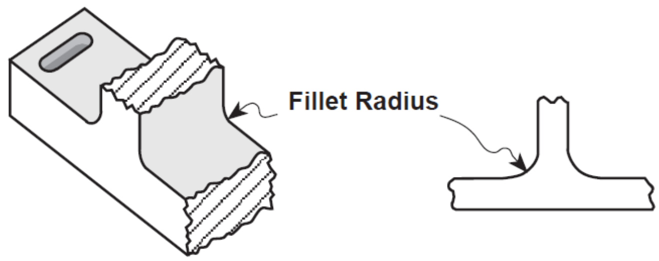
Dimension (Dim.) – Numerical value expressed in appropriate units of measure (inches, fractional inches, decimal inches, millimeters, degrees, etc.).

Drawing (Dwg.) – A graphic representation (sketch, blueprint, etc.) of an object. A collection of straight lines, curves and dimensions that shows the shape and size of an object.

Drilled Hole – A hole created or enlarged by a drill bit. Distinguished from a bored or reamed hole.

Engineers Scale- The chain or civil engineers, scale, commonly called the engineer's scale, is usually a triangular scale, containing six fully divided scales subdivided decimally, each major interval on a scale being subdivided into 10ths. Each of the six scales is designated by a number representing the number of graduations that particular scale has to the linear inch. On the 10 scale, for example, there are 10 graduations to the inch; on the 50 scale, there are 50. You can see that the 50 scale has 50 graduations in the same space occupied by 10 on the 10 scale. This space is 1 linear inch.

FIGURE 1-58
Fillet Radius

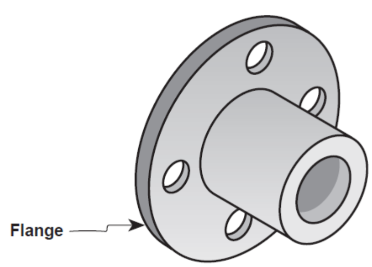


ERGONOMICS-Ergonomics (= the natural laws of work) is the study of humans at work, and deals with how people adapt themselves to their working conditions.

Fillet (Fill.) – A curved or rounded surface between two intersecting surfaces. Radius cast in the joint between intersecting surfaces of casting. (See Figure 1-58)

Flange – A projecting rim or rib used for strength, guidance, or as a means of attaching to another object. (See Figure 1-59)

FIGURE 1-59
Flange



Forging – The process by which metal is shaped by compressive force (hammer, press, rolls, etc.). May be accomplished while metal is hot or cold, depending upon manufacturing process.

FORM-Form describes the external plastic shape. It conveys the visual, aesthetic, and symbolic aspects of a product.

Gauge (GA) – A standard of reference for size or shape, for example, gauge block, thread gauge, etc.

Galvanize – To treat the surface of an item with an alloy composed mainly of zinc, in order to prevent rusting.

Gasket – A thin piece of rubber, metal, or suitable material placed between surfaces to make a sealed joint.

Gear – A wheel or disk, having teeth around its periphery, used to interlock with other gears to transmit motion.

Grind (G) – To remove material from, or reduce the size of a work piece by contact with an abrasive wheel. To finish or polish a flat or curved surface with an abrasive wheel. To sharpen with an abrasive wheel.

Harden (Hdn.) – The most important of the heat treating processes, hardening increases the tensile properties of metals. To harden metals by heating and cooling at pre-determined rates.

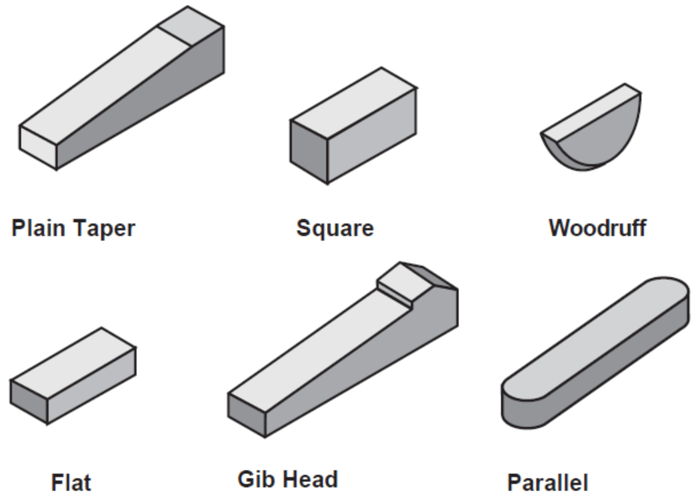
Heat Treat – To change the properties of a material by heating, then cooling.

Jig – A device for guiding a tool in cutting a piece. Usually, it holds the work in position. Also called a fixture.

Junction (Jct.) – The point of intersection of two or more lines, planes, axes or features.

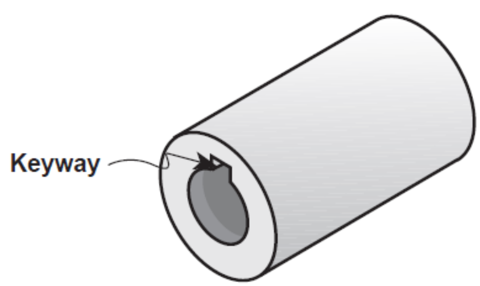
Key – A small piece of metal sunk into both shaft and hub to prevent rotation. (see Figure 1-60)

FIGURE 1-60
Keys



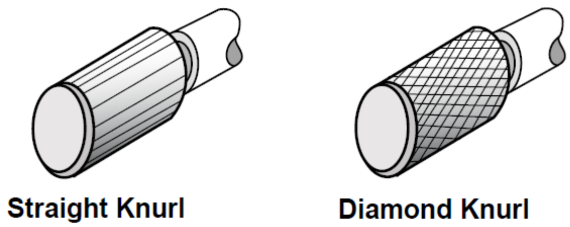
Keyway – In a mechanical power transmission system, the pocket in the driven element that is a driving surface for key. A groove or channel in a shaft or the hole of a gear or pulley that fits a key to prevent joint slippage. (see Figure 1-61)

FIGURE 1-61
Keyway



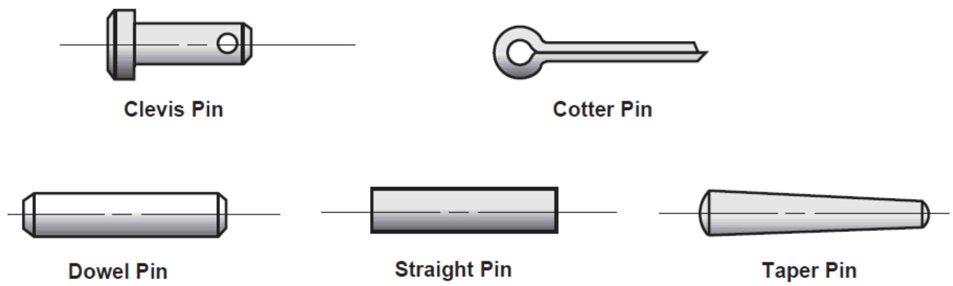
Knurl – To impress a pattern of dents in a turned surface with a special lathe tool to produce a better hand grip. (See Figure 1-62)

FIGURE 1-62
Knurl



Machine Pins – Semi-permanent fasteners for parts which are to be assembled and disassembled. (See Figure 1-64)

FIGURE 1-64
Machine Pins



Machine Steel (MS) – Free-machining, general-purpose, plain carbon steel with a 0.2 to 0.3% carbon content.

Magnaflux (M) – Trade name for non-destructive magnetic particle materials testing method, which is used only on magnetic steels to identify cracks.

Magnesium (Mag. or Mg) – A silver-white, lightweight, malleable, ductile metal.

MODEL CONSTRUCTION PROCEDURE-In model construction, a real or planned template is created in a three-dimensional, physical object.

MULTI-JET MODELLING-Multi-jet modelling (MJM) is a manufacturing process in the area of rapid prototyping.

National Coarse (NC) – A screw thread designation for a coarse thread.

National Extra-Fine (NEF) – A screw thread name for an extra-fine thread.

National Fine (NF) – A screw thread designation for a fine thread.

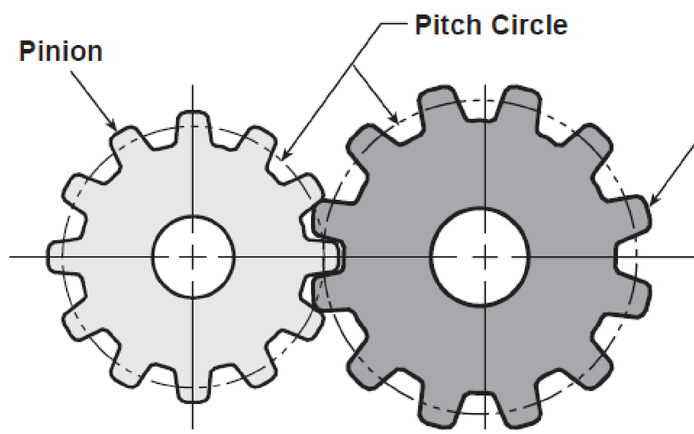
National Pipe Threads (NPT) – American National Standard Taper Pipe Threads. A 60°-thread form for pipe.

ORTHOGRAPHIC PROJECTION—A method of projection with six principal views.

Outside Diameter (OD) – The length of a line drawn through the center of a cylinder or sphere, terminating at the outside circumference on each end.

Pinion – The smaller of two mating gears. (see Figure 1-65)

FIGURE 1-65
Pinion



Pitch (P) – In a screw thread, the distance from a point on a thread to the same point on an adjacent thread.

Pitch Circle – An imaginary circle corresponding to the circumference of the friction gear from which the spur gear was derived.

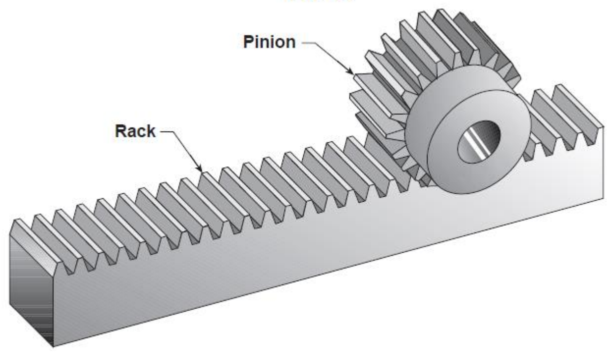
Pitch Diameter (PD) – The diameter of an imaginary circle on a gear that separates the addendum and dedendum of the tooth. RPM calculations for gears are based on this circle, because (theoretically) the pitch circles of mating gears are tangent.

PROTOTYPE - In technology and industrial design, the term “prototype” describes the experimental model of a new development.

PVC-Polyvinyl chloride (abbreviated to PVC) is a plastic whose elasticity can be broadly varied and adapted to different applications through the addition of various substances.

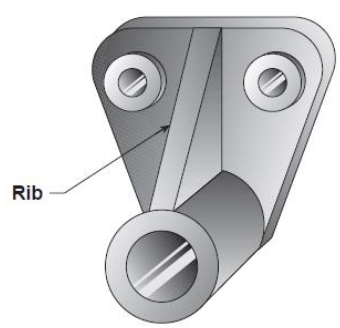
Rack – Flat bar with gear teeth in a straight line to engage with teeth in gear. Also, a gear with an infinite radius. (see Figure 1-66)

FIGURE 1-66
Rack



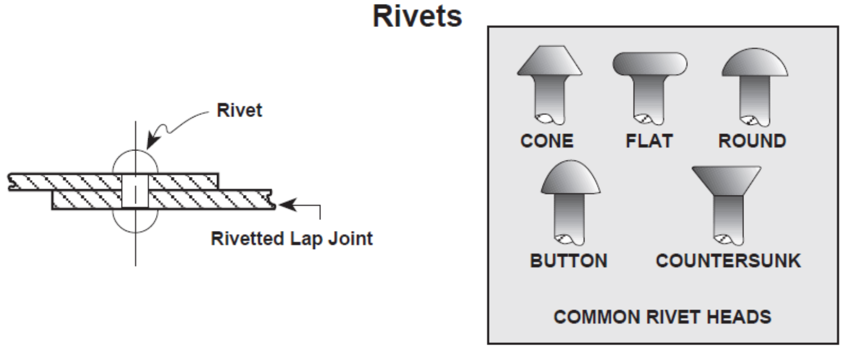
Rib – A relatively thin, flat member acting as a support. Also see web and gusset. (see Figure 1-67)

FIGURE 1-67
Rib



Rivet – To fasten by rivets, or to clench over the end of a pin spreading the end. (See Figure 1-68).

FIGURE 1-68
Rivets



Section or Sectional View (Sec.) – The graphic removal of a portion of an object to reveal internal lines and surfaces.

SELECTIVE LASER SINTERING-selective laser sintering (SLS) is a procedure used in prototype construction for the rapid production of models or component samples whose spatial structure created layer by layer.

Shim – A thin piece of metal or material used as a spacer in adjusting two parts.

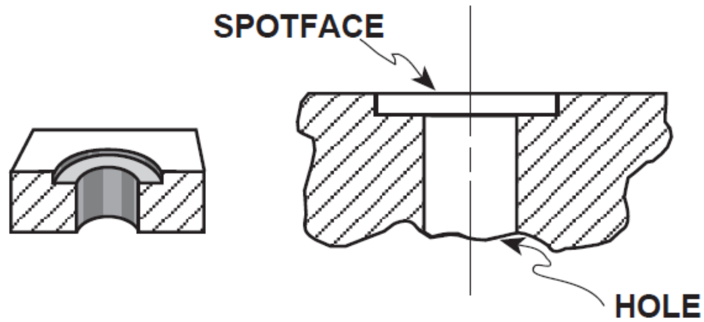
Society of Automotive Engineers (SAE) – Organization that promotes all aspects of the design, construction and use of self-propelled mechanisms, prime movers, their components and related equipment.

Socket Head (Skt. Hd.) – The head of a screw fastener in which a hexagonal shaped pocket is recessed. Tightened with an Allen wrench or hexagonal key. Standard for cap crews.

Solder – To join two parts with an alloy composed of lead and tin.

Spot Face (Spt. Fc.) – The machining of a circular area around a hole in a weldment or casting to provide a flat, smooth surface to accept the head of a fastener. (See Figure 1-70)

FIGURE 1-70
Spot Face

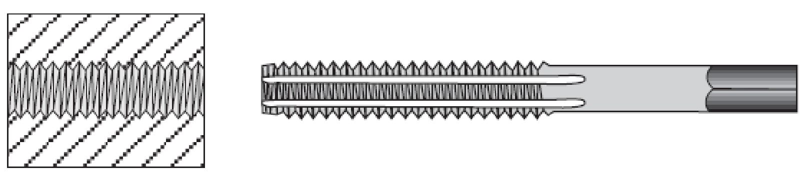


STEREOLITHOGRAPHY-Stereolithography (STL or SLA) is another computer-supported process in the area of rapid prototyping (and rapid manufacturing).

TACTILE DESIGN-Tactile design focuses on the sense of touch. Along with functionality and ergonomics, it plays a central role in product design.

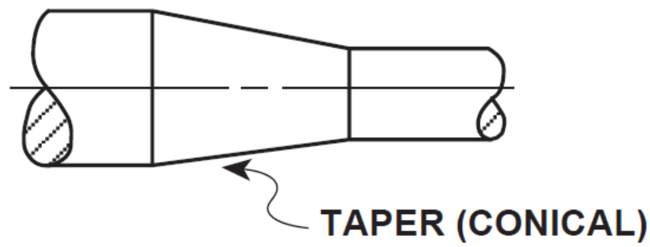
Tap – A cutting tool used to form internal screw threads. (See Figure 1-71)

FIGURE 1-71
Tap



Taper – Gradually changing shape given to a shaft, hole or part. (see Figure 1-72)

FIGURE 1-72
Taper



Template – A guide or pattern used to mark out work, guide the tool in cutting it or to check the finished product. Tensile Strength (Ten. Str.) – The maximum stress that a material subjected to a stretching load can withstand without tearing. Also called hot strength. Thread, Threading (Thd.) – The interior or exterior continuous helical rib on a screw or pipe used to join and hold parts together. To cut screw threads in a material. Thru Hole (Thru) – The depth of a hole in a part that goes "all the way through."

Tensile Strength-The value obtained by dividing the maximum load observed during tensile straining by the specimen cross-sectional area before straining. Also called "Ultimate Strength". It is usually expressed in pounds per square inch.

Unified National Coarse (UNC) – The unified U.S., United Kingdom and Canadian screw thread form having a National Coarse designation.

Unified National Fine (UNF) – The unified United States, United Kingdom and Canadian screw thread form having a National Fine designation.

U**nified National Special (UNS)** – The unified United States, United Kingdom and Canadian screw thread form having a special designation.

Unified Thread Form (U) – The United States, United Kingdom and Canadian screw thread form having a radius at the root instead of a flat as in the National system. The National and Unified forms are interchangeable.

Volume (Vol.) – The measure of the size of an object or defined region in three-dimensional space. The product of height x width x depth, measured in cubic units: cubic feet, cubic inches, cubic centimeters, etc.

Web – A thin, metal section between the ribs, bosses or flanges of a casting to add strength. In a forging, the thin metal section remaining at the bottom of a depression or at the location of the punches.

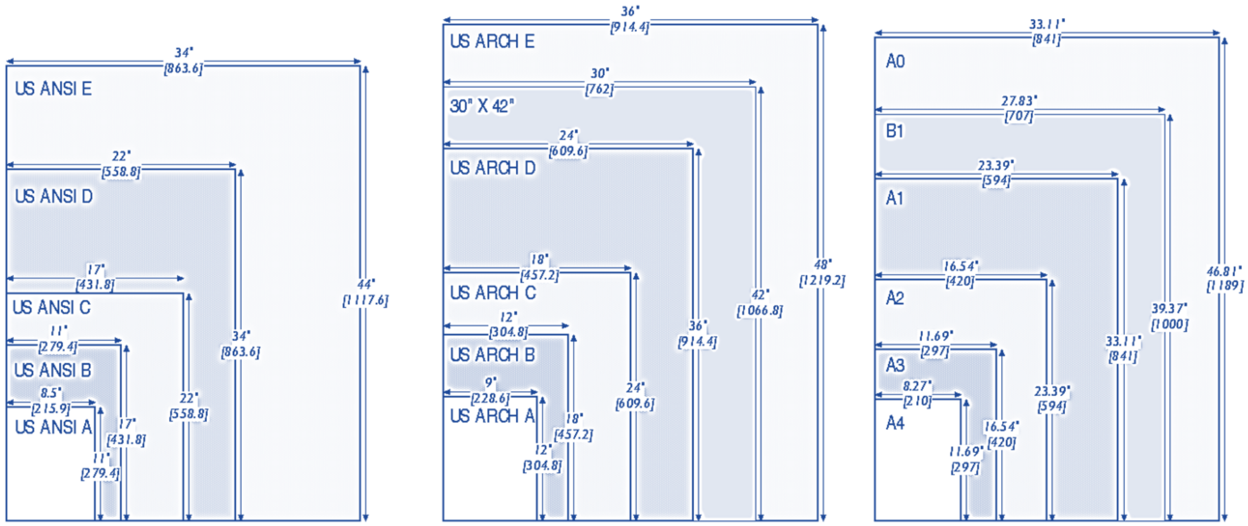
Weight (Wt.) – The gravitational force with which the Earth attracts a body or object measured in pounds, ounces, kilograms or grams.

Yard (Yd.) – A unit of length used in the United States and United Kingdom equal to 3 ft., 36 in., or 0.9144 meters.

GUIDE TO STANDARD PAPER SIZES

Scale: 1" = 1' - O"

US ANSI	ARCHITECTURAL	METRIC



ANSI (American National Standards Institute) paper sizes are proportional to the common letter size sheet.

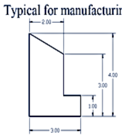
Architectural sheet sizes are based upon a 36" x 48" sheet, and proportionally smaller sizes. In addition to the above, the 24" x 42" sheet size is commonly accepted as a standard size.

The metric "A" series is based upon an A0 sheet being one square metre in area. Although the B1 sheet is in the "B" series, it has come to be commonly accepted.

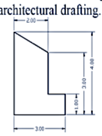
In order to have less changing of paper rolls in our Océ digital system, we print metric sizes on ANSI paper, e.g. an A0 print would be centered on a 34" high sheet.

Dimensioning Systems

- **Unidirectional –** All dimensions read from the bottom of the drawing sheet. Typical for manufacturing drafting.



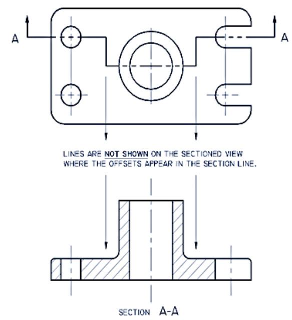
- **Aligned –** Dimensions aligned with the dimension line. Dimensions read from the bottom and right side of the drawing sheet. Typical for architectural drafting.



Dimensioning Geometry

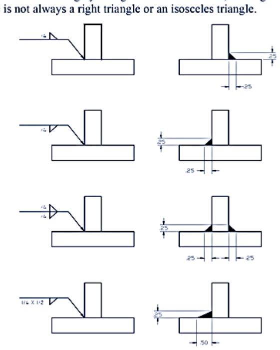
Offset Section

To include features that do not appear in a straight line, the cutting plane may be offset to pass through the features. Offsets or bends created by the cutting plane are not shown on the section view.



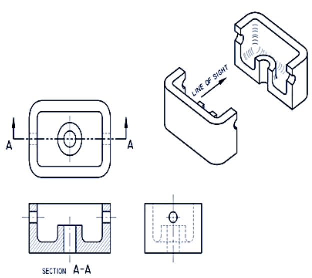
Fillet Welds

A fillet weld is used to make lap joints, corner joints, and T joints. The fillet weld is roughly triangular in cross-section, although its shape is not always a right triangle or an isosceles triangle.



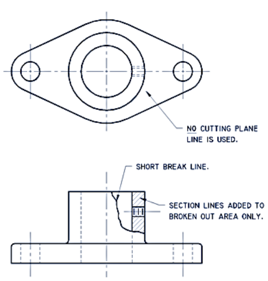
Full Section

The cutting plane line extends straight though the object, generally at the centerline of symmetry.



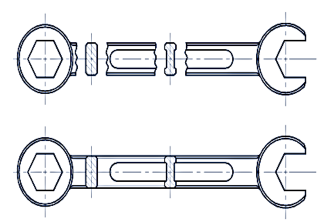
Broken-Out Section

Where only a portion of the object needs to be shown in the section. The section is limited by a short (freehand) break line. No cutting plane line is required.



Revolved Section

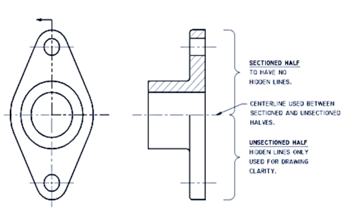
A cutting plane line is passed through the object and revolved 90° in place towards the plane of the drawing. Used to show the cross section of a spoke, bar, rib, etc.



Half Section

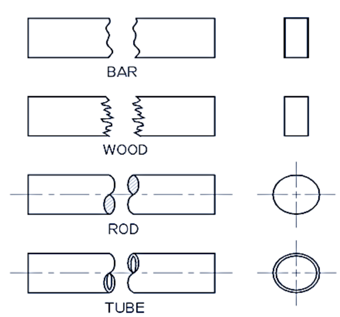
The cutting plane passes half way through the object, removing one fourth of the object.

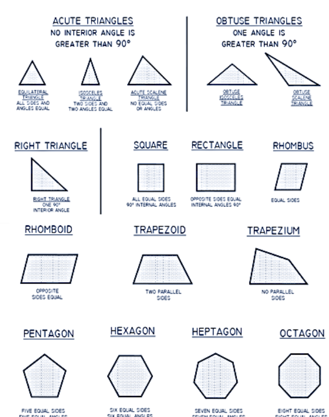
- Half sections are most applicable to symmetrical objects to show both the interior and exterior in a single view.
- A centerline is used between the sectioned and the unsectioned half.



Conventional Breaks

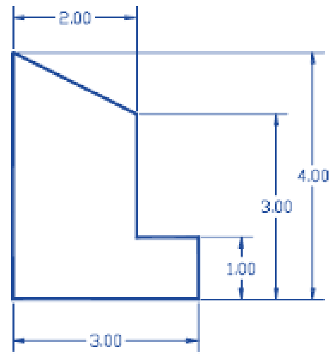
Used to shorten long features.



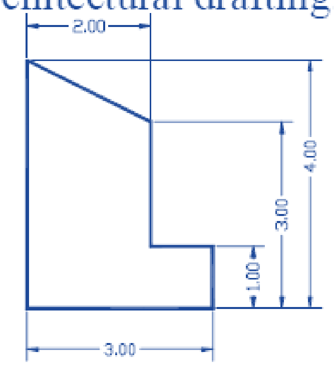


Dimensioning Systems

- **Unidirectional** – All dimensions read from the bottom of the drawing sheet. Typical for manufacturing drafting.



- **Aligned** – Dimensions aligned with the dimension line. Dimensions read from the bottom and right side of the drawing sheet. Typical for architectural drafting.



Dimensioning Geometry

- Review the proper methods of dimensioning arcs, angles, chamfers, etc.

Fraction, Decimal, and Metric Equivalents

INCHES		MILLI-METERS
FRACTIONS	DECIMALS	
	.00394	.1
	.00787	.2
	.01181	.3
1/64	.015625	.3969
	.01575	.4
	.01969	.5
	.02362	.6
	.02756	.7
1/32	.03125	.7938
	.0315	.8
	.03543	.9
	.03937	1.00
3/64	.046875	1.1906
1/16	.0625	1.5875
5/64	.078125	1.9844
	.07874	2.00
3/32	.09375	2.3813
7/64	.109375	2.7781
	.11811	3.00
1/8	.125	3.175
9/64	.140625	3.5719
5/32	.15625	3.9688
	.15748	4.00
11/64	.171875	4.3656
3/16	.1875	4.7625
	.19685	5.00
13/64	.203125	5.1594
7/32	.21875	5.5563
15/64	.234375	5.9531
	.23622	6.00
1/4	.2500	6.35
17/64	.265625	6.7469
	.27559	7.00
9/32	.28125	7.1438
19/64	.296875	7.5406
5/16	.3125	7.9375
	.31496	8.00
21/64	.328125	8.3344
11/32	.34375	8.7313
	.35433	9.00
23/64	.359375	9.1281
3/8	.375	9.525
25/64	.390625	9.9219
	.3937	10.00
13/32	.40625	10.3188
27/64	.421875	10.7156
	.43307	11.00
7/16	.4375	11.1125
29/64	.453125	11.5094

INCHES		MILLI-METERS
FRACTIONS	DECIMALS	
15/32	.46875	11.9063
	.47244	12.00
31/64	.484375	12.3031
1/2	.5000	12.70
	.51181	13.00
33/64	.515625	13.0969
17/32	.53125	13.4938
35/64	.546875	13.8907
	.55118	14.00
9/16	.5625	14.2875
37/64	.578125	14.6844
	.59055	15.00
19/32	.59375	15.0813
39/64	.609375	15.4782
5/8	.625	15.875
	.62992	16.00
41/64	.640625	16.2719
21/32	.65625	16.6688
	.66929	17.00
43/64	.671875	17.0657
11/16	.6875	17.4625
45/64	.703125	17.8594
	.70866	18.00
23/32	.71875	18.2563
47/64	.734375	18.6532
	.74803	19.00
3/4	.7500	19.05
49/64	.765625	19.4469
25/32	.78125	19.8438
	.7874	20.00
51/64	.796875	20.2407
13/16	.8125	20.6375
	.82677	21.00
53/64	.828125	21.0344
27/32	.84375	21.4313
55/64	.859375	21.8282
	.86614	22.00
7/8	.875	22.225
57/64	.890625	22.6219
	.90551	23.00
29/32	.90625	23.0188
59/64	.921875	23.4157
15/16	.9375	23.8125
	.94488	24.00
61/64	.953125	24.2094
31/32	.96875	24.6063
	.98425	25.00
63/64	.984375	25.0032
1	1.0000	25.4000