

FUNDAMENTALS of MECHANICAL DRAFTING

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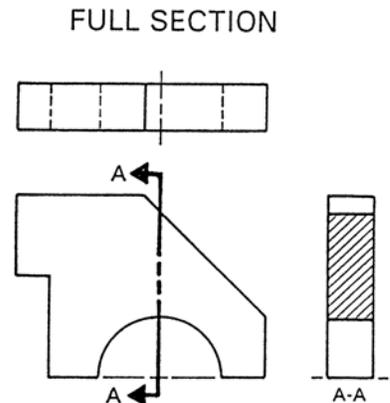
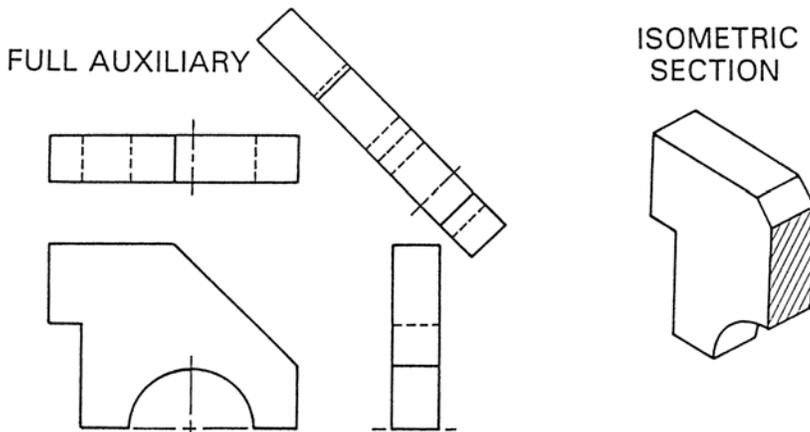
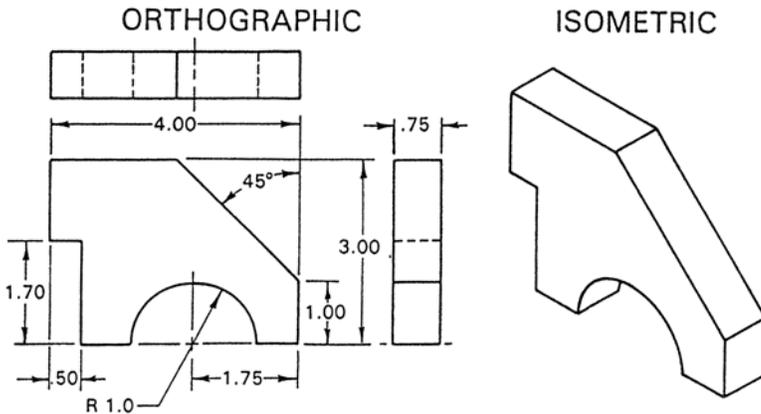
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TO THE STUDENT

This text is a comprehensive drafting book designed to teach the basic drawing techniques common to most areas of engineering drafting. The materials have been carefully prepared and illustrated to easily understand examples of each type of engineering drawings for a beginning course. The exercises are aligned in a practical order, progressing from simple to complex. The drawing assignments may be completed with manual drafting techniques, freehand sketching, or with a CAD system. This book can be used in conjunction with any other drafting text or with no text at all. All the materials incorporate the current standards of ASME Y14.5M 1994 (American Society of Mechanical Engineers). Page layouts and gridded pages in the back of the text may be copied for student's drawing assignments.

As each instructor will have her or his priority of emphasis, the materials may be reorganized to fit the program's needs. Students using this textbook may advance at their own pace. The instructor may wish to supplement the material with class demonstrations and other course work. The instructor may make transparencies from this text for the overhead projector to help with class presentations.

When studying the objects in this textbook, you will learn that each line and shape is a surface or an edge of an object. This will teach you to organize the layout for your drawings. With proper application and practice, you will acquire the knowledge and drafting skills for mechanical drawing.

UNIT 1

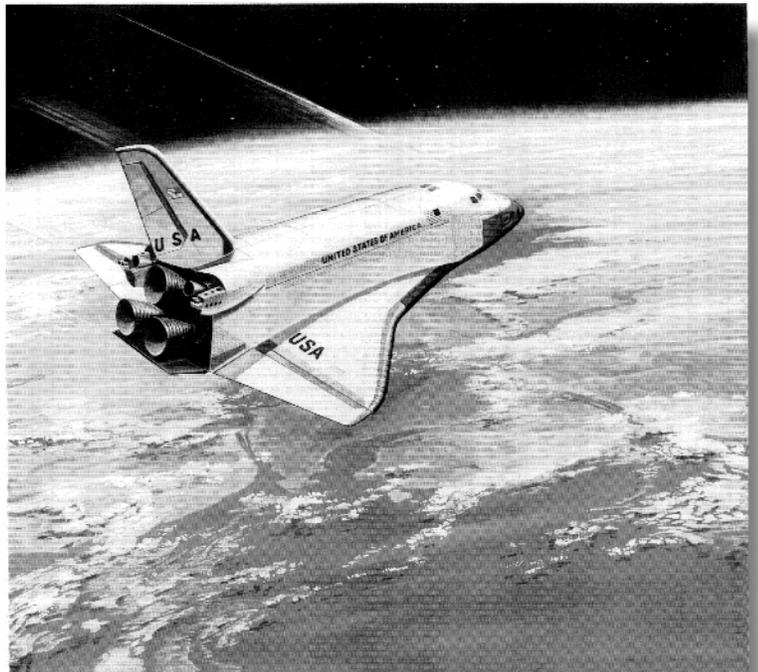
AN INTRODUCTION TO DRAFTING

This textbook uses a visual approach to learning how to read, plan, and draw mechanical drawings. Students will study and visualize how a drafter would solve layouts for a drawing.

Industry requires many millions of drawings every year. Every part must have a working drawing. These drawings communicate the details to a skilled craftswoman or man so the item can be correctly manufactured. It has taken more than 100,000 working drawings to be able to manufacture the space shuttle.

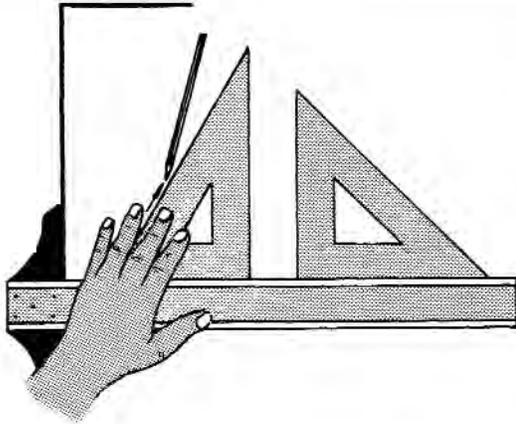
The people who make these drawings are called drafters. There are several different levels within the drafting profession:

1. Chief designers create, plan, and draw designs with the engineers and scientists.
2. Senior detailers make the difficult and more complicated drawings.
3. A checker looks for errors and requested ECO's (engineering change orders).
4. A detailer makes the needed changes on existing drawings.
5. The drafter does most of sketches, manual drafting, and CAD drawings.

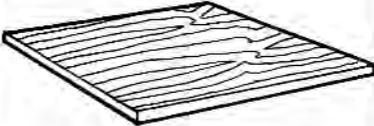
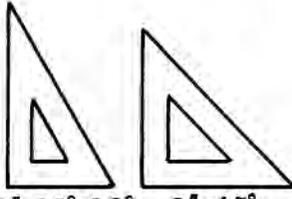
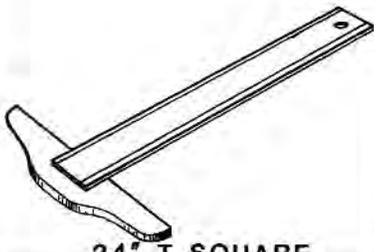
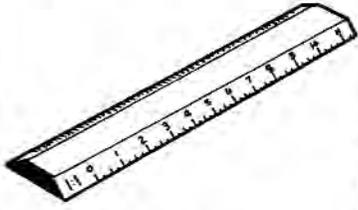
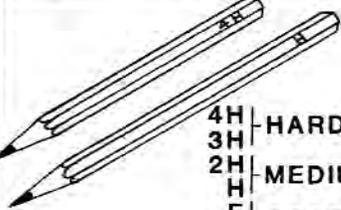
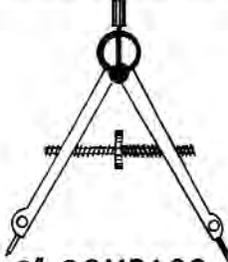
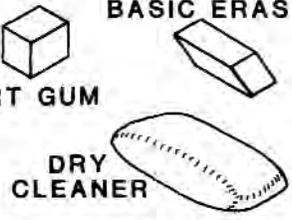
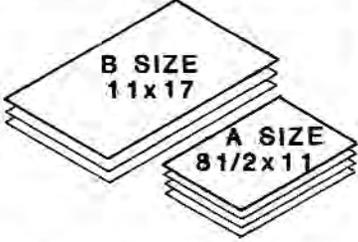
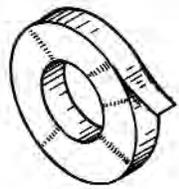
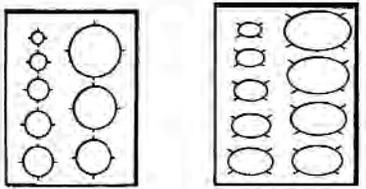
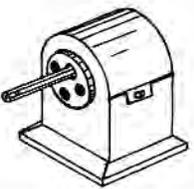
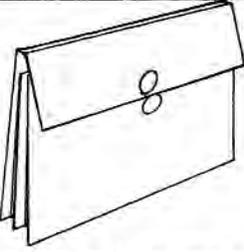


UNIT 2

DRAFTING EQUIPMENT



The basic tools of mechanical drafting are shown in the illustrations below. These are the tools that the beginner must have. For advanced drawing techniques, additional equipment will be necessary.

 <p>20"x26" DRAWING BOARD</p>	 <p>10" 30°-60° 8" 45° TRIANGLES</p>	 <p>24" T SQUARE</p>
 <p>12" SCALE</p>	 <p>4H HARD 3H 2H MEDIUM H F HB SOFT</p> <p>DRAFTING PENCILS</p>	 <p>6" COMPASS</p>
 <p>BASIC ERASER ART GUM DRY CLEANER</p> <p>ERASERS/CLEANERS</p>	 <p>B SIZE 11x17 A SIZE 8 1/2 x 11</p> <p>DRAFTING PAPER</p>	 <p>DRAFTING TAPE</p>
 <p>CIRCLE ISOMETRIC</p> <p>TEMPLATES</p>	 <p>PENCIL SHARPENER</p>	 <p>12x19 ENVELOPE</p>

DRAWING ONE OR TWO TANGENTS TO TWO CIRCLES

<p>① To make the construction above:</p>	<p>② Repeat circle "O'" at "O."</p>	<p>③ Use radius "O'O". Swing arc "LOM" from "O'."</p>	<p>④ Extend "OL" to "N" and "OM" to "P."</p>	<p>⑤ Draw "O'Q" parallel to "ON." Draw "O'R" parallel to "OP."</p>	<p>⑥ Draw tangent lines "NQ" and "PR."</p>

A WORKING KNOWLEDGE OF ANGLES

<p>① The 30° line (AB) will intersect a 60° line (CD) at right angles.</p>	<p>② The 60° line (AB) will intersect a 30° line (CD) at right angles.</p>	<p>③ These 45° lines intersect each other at right angles.</p>

MEASURING FOR EVENLY SPACED OBLIQUE LINES

<p>① To draw the above:</p>	<p>② Draw the diagonal as shown.</p>	<p>③ Measure the spaces on the diagonal.</p>	<p>④ Draw through the marks.</p>

HOW TO USE A PROTRACTOR

<p style="text-align: center;">PROTRACTOR</p>				
	<p>① Draw line "AB," mark point "C."</p>	<p>② Place protractor along the line "AB," with arrow at point "C."</p>	<p>③ Mark graduated point 72 for an angle of 72°.</p>	<p>④ Angle "DCB" is an angle of 72°.</p>

DIVIDING A LINE INTO A GIVEN NUMBER OF PARTS (METHOD 1)

<p>① To divide line "AB" into three equal parts, draw vertical line "BC":</p>	<p>② Place the end of the ruler on "A." Swing the ruler up or down until:</p>	<p>③ Some number divisible by 3 (6) touches line "BC." Mark 2 and 4.</p>	<p>④ Project upward vertically from 2 and 4. "AD" = "DE" = "EB."</p>

DIVIDING A LINE INTO A GIVEN NUMBER OF PARTS (METHOD 2)

<p>① To divide "AB" into seven equal parts: Draw "AK" at any angle to "AB."</p>	<p>② Starting at "A," measure seven equal spaces along "AK." Draw a line from the seventh mark (C) through "B."</p>	<p>③ Draw lines parallel to "CB" from 1, 2, 3, 4, 5, and 6.</p>	<p>④ "AD" = "DE" = "EF" = "FG," etc.</p>

FINDING FRACTIONAL PARTS OF ANY DISTANCE

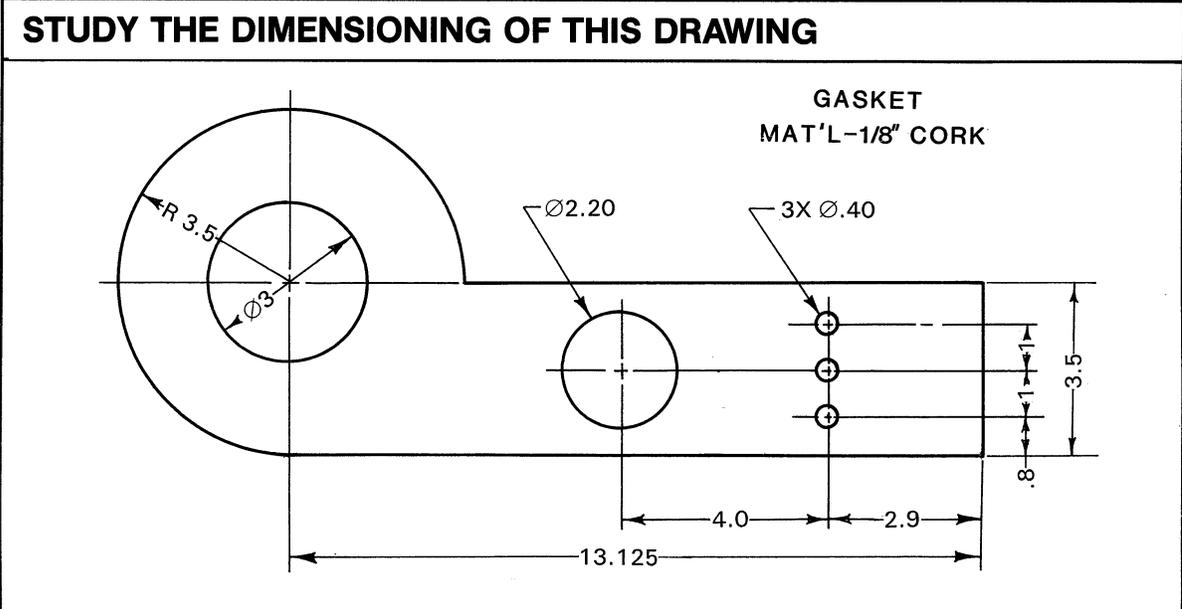
<p>$AC = \frac{3}{4} AB$</p> <p>① To find $\frac{3}{4}$ of "AB": Divide "AB" into 4 parts. Three of the parts equals three fourths.</p>	<p>$AC = \frac{7}{8} AB$</p> <p>② To find $\frac{7}{8}$ of "AB": Divide "AB" into 8 parts. Seven of the parts equals seven-eighths.</p>	<p>$AC = \frac{4}{3} AB$</p> <p>③ To find $\frac{4}{3}$ of "AB": Divide "AB" into 3 parts. Swing "BD" to "C." "AC" = $\frac{4}{3}$ of "AB."</p>	<p>$AC = 1\frac{1}{2} AB$</p> <p>④ To find $1\frac{1}{2}$ "AB": Divide "AB" into 2 parts. Swing "BD" to "C." "AC" will then be $1\frac{1}{2}$ "AB."</p>

DIMENSIONING CIRCLES

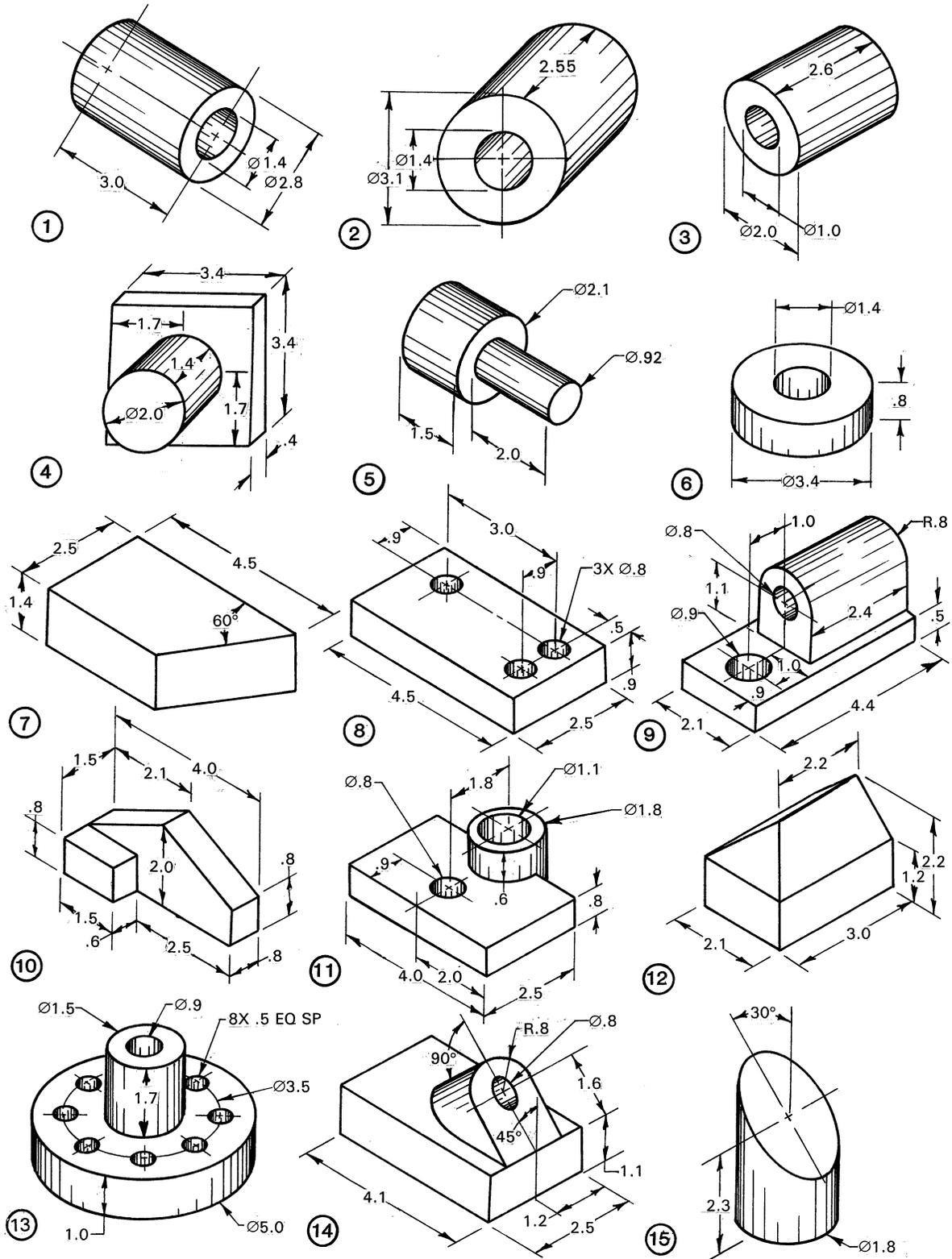
The dimension for a hole or a cylinder is indicated by giving its diameter (\varnothing).
The dimension for an arc is indicated by giving the radius (R) of the arc.

THE "LEADER"					
① A leader is a bent dimension line with an arrow.	② The arrowhead must touch the circumference of the circle.	③ The arrow must point towards the center of the circle.	④ Never dimension to a hidden line.	⑤ The symbol for diameter is \varnothing .	⑥ The dimension should be centered to the leader.

SIZE DIMENSIONS OF CIRCLES				
① The only method used to dimension small circles.	② The same method is used for medium sized circles.	③ For large circles, the dimension may be placed inside the circle.	④ The \varnothing symbol with this situation is optional.	⑤ The leader is used to get the dimension clear of the drawing.



NOTE THE PLACEMENT OF THE DIMENSIONS ON THE PICTORIAL DRAWINGS



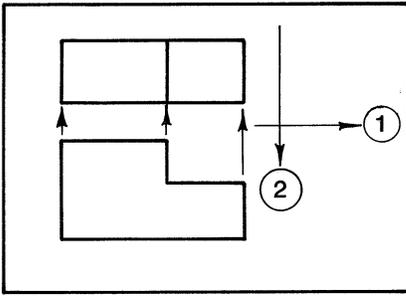
ASSIGNMENT

Draw and dimension the pictorial drawings.

ORTHOGRAPHIC PROJECTION

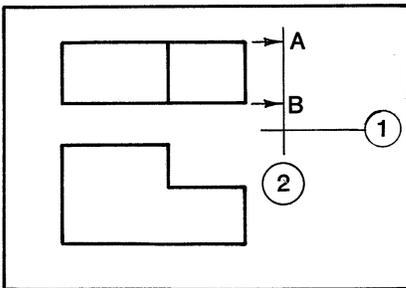
This is a very important lesson in mechanical drawing.

①



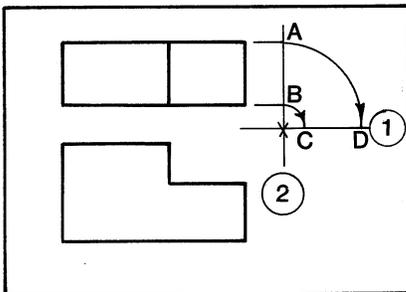
- A. Draw the front view.
- B. Project upward from the front view.
- C. Measure and draw the top view. (Leave a 1" space between the front view and the top view.)
- D. Draw a light horizontal line ① about 1/2" below the top view. Extend this line to the right as shown.
- E. Draw a light vertical line ② about 1/2" to the right of the top view as shown.

②



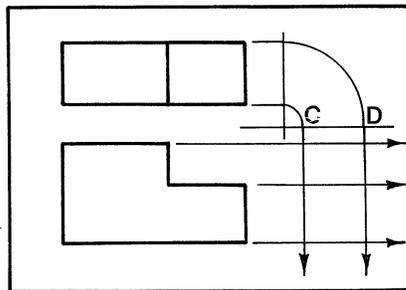
- A. Extend the top horizontal edge of the top view until it touches line ② at point "A."
 - B. Extend the bottom horizontal edge of the top view until it touches line ② at point "B."
- Basic Rule:** Extend every horizontal line in the top view until it touches line ②.

③



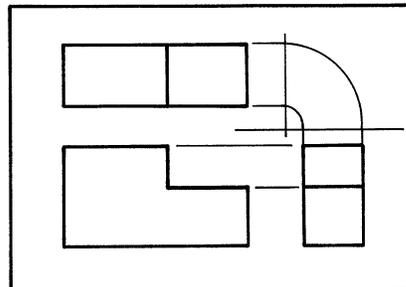
- A. Put your compass needle at the point where lines ① and ② cross (marked "X").
 - B. Open the compass from "X" to "B."
 - C. Swing arc "BC" until it touches line ① at "C."
 - D. Open the compass from "X" to "A." Swing "AD."
- Basic Rule:** Swing every line that touches line ② downward until it touches line ①. (Always use "X" as the center.)

④



- A. Drop a vertical line downward from "C."
 - B. Drop a vertical line downward from "D."
 - C. Extend the three horizontal edges of the front view toward the right as shown. (You can now see the end view.)
- Basic Rule:** Drop every line that touches line ① vertically in order to help make the end view.

⑤



DARKEN THE END VIEW

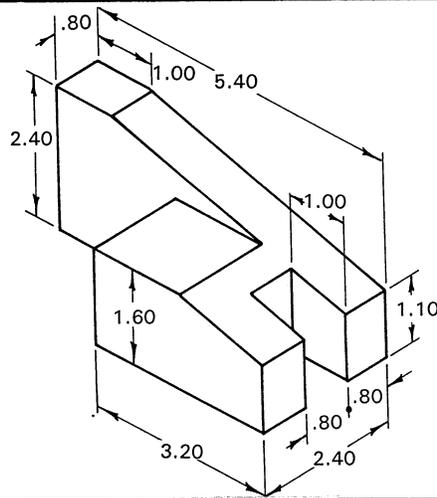
This is the method used by drafters when they wish to make an orthographic projection.

Learn this method . . . thoroughly!

In a short time, this method of projection will become automatic with you.

UNIT 11

PICTORIALS



Working drawings are a two-dimensional drawing that describes the items to be manufactured. It is therefore critical that the drafter have a thorough understanding of the principles of multiview drawing and orthographic projection so the working drawing they create can be easily read (blueprint reading) with clear instructions to the manufacturer.

It is also important for the many non-technical people in industry and business to be able to visualize the items in the working drawings. To help the non-technical individual, a pictorial drawing is drawn of the items. A pictorial drawing is like a "picture".

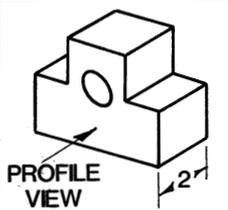
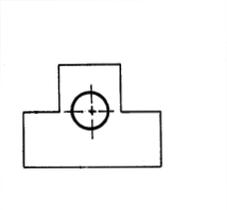
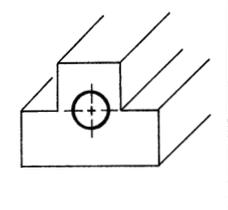
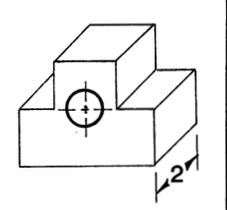
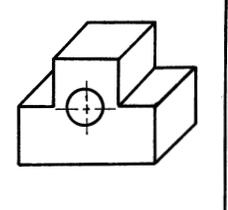
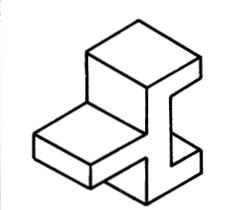
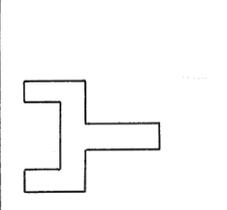
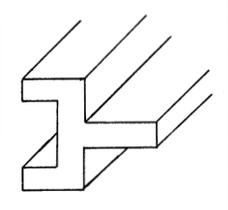
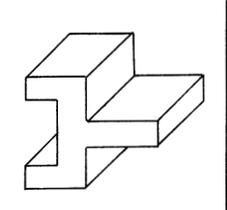
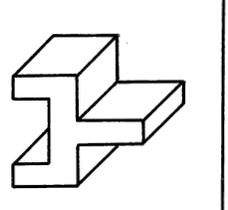
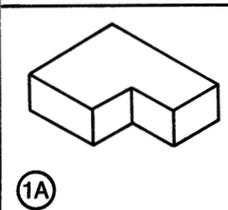
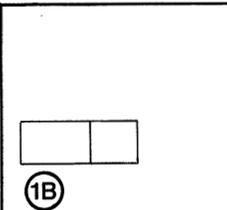
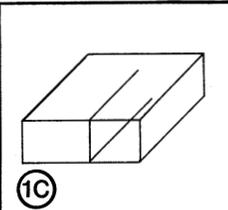
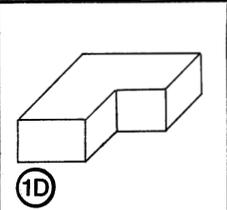
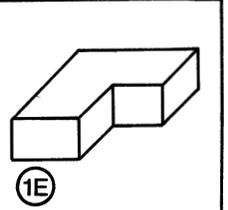
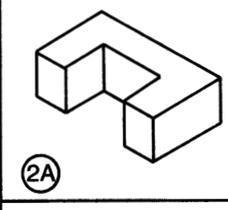
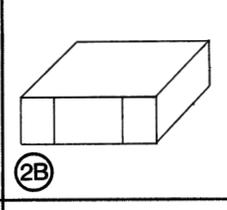
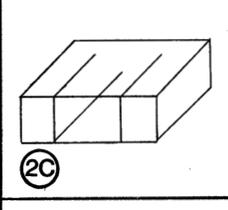
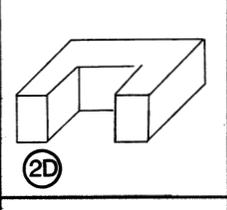
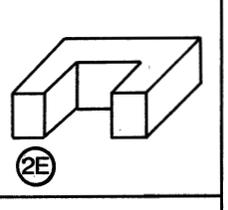
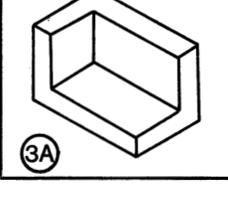
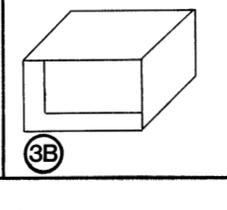
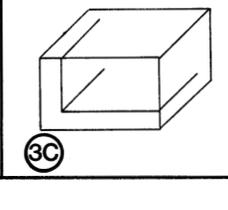
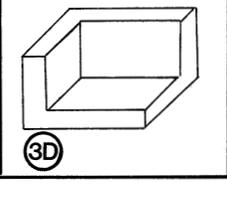
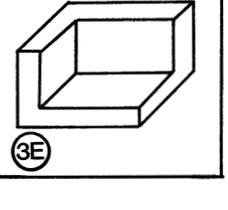
Shown below are the various types of pictorial drawings used for industrial drafting.

TYPES OF PICTORIAL DRAWINGS

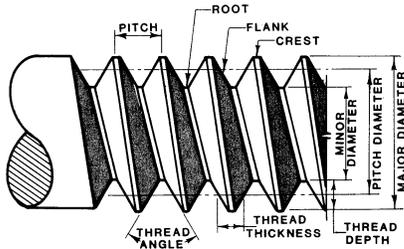
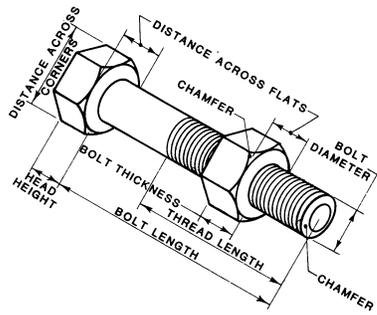
AXONOMETRIC	OBLIQUE	PERSPECTIVE
<p>ISOMETRIC</p>	<p>CAVALIER</p> <p>FULL SIZE</p>	<p>ONE-POINT PERSPECTIVE</p>
<p>DIMETRIC</p>	<p>CABINET</p> <p>HALF SIZE</p>	<p>TWO-POINT PERSPECTIVE</p>
<p>TRIMETRIC</p>		

OBLIQUE DRAWINGS

There are two kinds of oblique drawings: cavalier and cabinet. A cavalier drawing and a cabinet drawing are drawn in the same manner, except that a cavalier drawing is always made to the exact measurements of the object. In a cabinet drawing, receding surfaces are drawn one-half size.

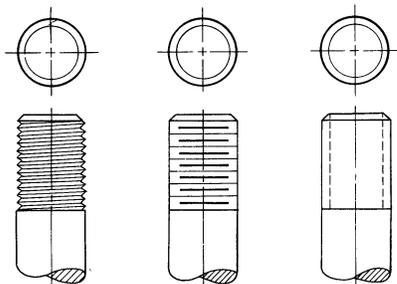
HOW TO MAKE AN OBLIQUE DRAWING (Step by Step)				
				
① To make an oblique drawing of this object, select the profile view .	② Draw the profile view as you would draw the front view .	③ Project back and to the right at 45° (30° may be used).	④ Measure the thickness and draw the back edge.	⑤ Darken the finished oblique drawing (cavalier).
REVOLVE THE OBJECT TO OBTAIN THE FRONT VIEW				
				
① Before the oblique drawing is made, this object should be revolved.	② Draw the front view .	③ Project back at 45° (or 30°).	④ Measure the thickness and draw the back edge.	⑤ Darken the oblique drawing (cavalier).
NOTICE THE DETAILS OF THESE CAVALIER DRAWINGS				
				
				
				

Parts of External Threads



Parts of a threaded fastener

External Thread Symbols

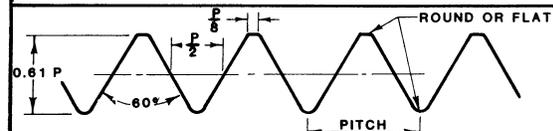


PICTORIAL SYMBOL SCHEMATIC SYMBOL SIMPLIFIED SYMBOL

Three types of thread symbols. The simplified symbol is preferred.

A basic rule in drafting is to pick the quickest drawing method to communicate the ideas and concepts to the fabricator. All three methods of thread representation are acceptable on a drawing, but the simplified version of drawing threads is recommended because it will save time.

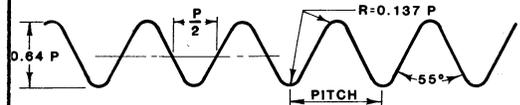
Types of External Threads



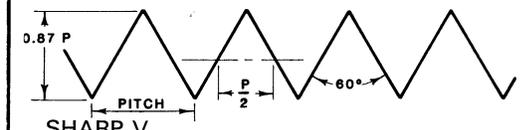
UNIFIED THREAD SYSTEM (U.S. STANDARD)



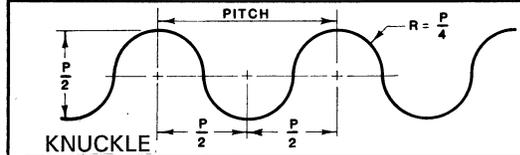
AMERICAN NATIONAL



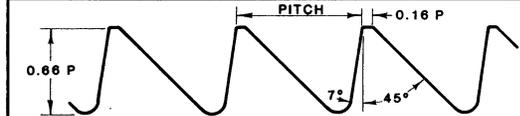
BRITISH STANDARD WHITWORTH



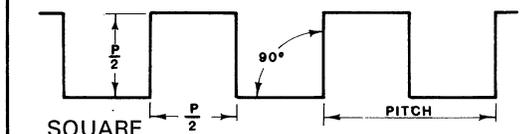
SHARP V



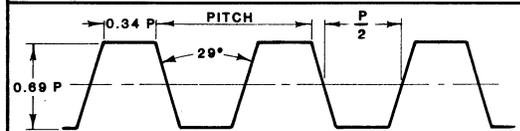
KNUCKLE



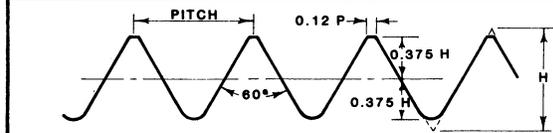
BUTTRESS



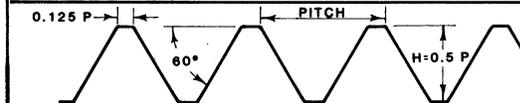
SQUARE



WORM



ISO METRIC

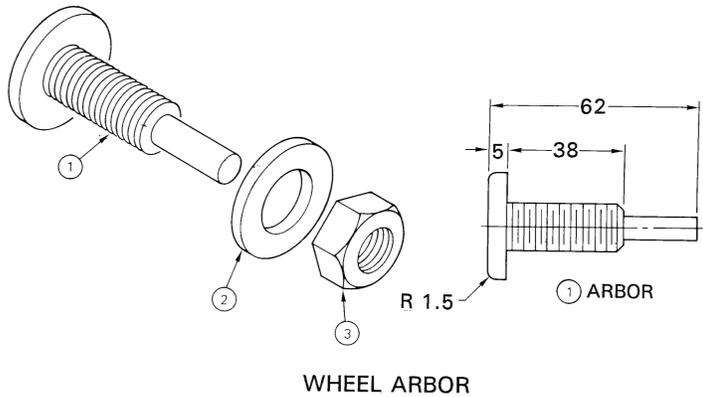


OMFS METRIC

Profiles of 10 types of threads

UNIT 15

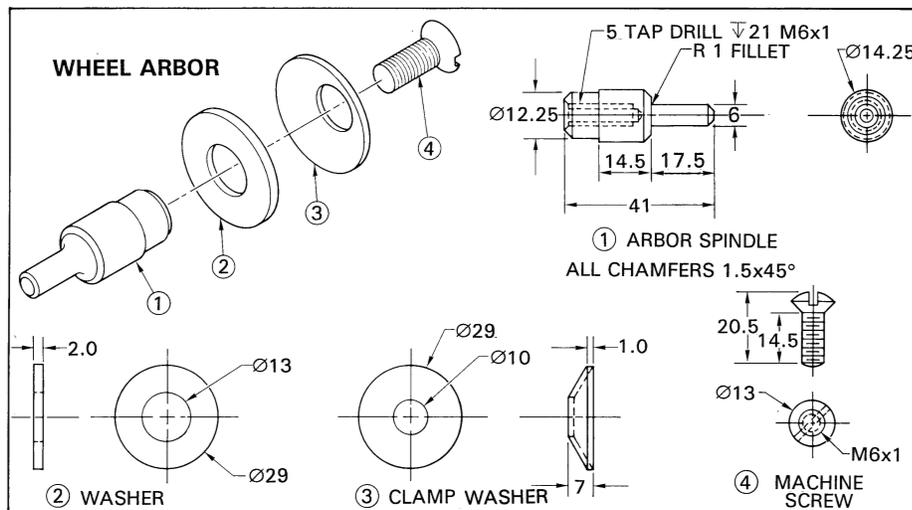
WORKING DRAWINGS



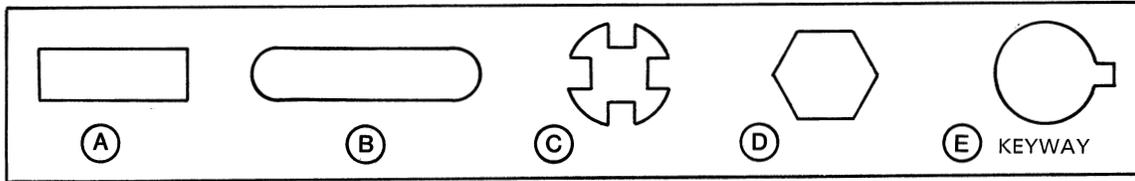
The purpose of a working drawing is to accurately describe and provide directions for the production of an item. These directions include notes, dimensions, and all the line work needed for fabricators. Working drawings may be used by a patternmaker, a foundry worker, a machinist, and many other skilled workers.

The drafter needs a working knowledge of the field of manufacturing for the item he or she is drawing. An efficient drafter must be familiar with the limitations and possibilities of each step of the manufacturing process, such as machining, casting, and welding.

This chapter will cover only the most commonly used steps in industrial fabrication. For additional information, refer to advanced texts, machinist handbooks, and experienced experts in each particular field.

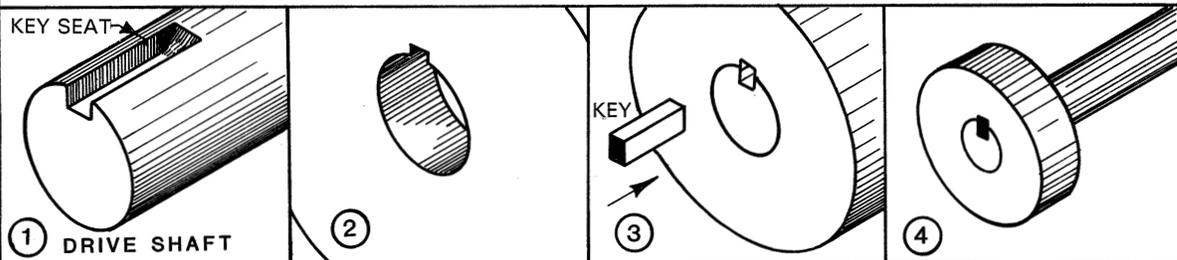


BROACHING



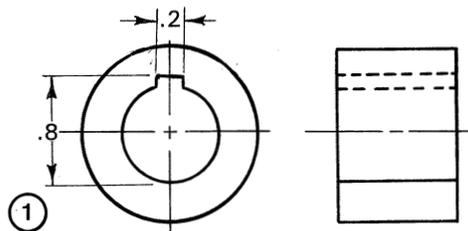
A broaching machine can produce many types of holes that would be otherwise difficult to produce.

THE NEED FOR A KEY AND A KEYWAY



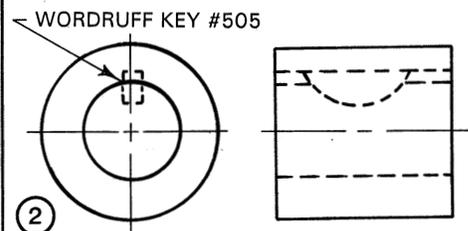
- ① A groove, called a **key seat**, is cut in the end of a drive shaft.
- ② A **keyway** is broached in the hub of a pulley.
- ③ The two slots are aligned and a metal **key** is slipped into place.
- ④ When the drive shaft turns, the pulley also must turn.

DRAWING AND DIMENSIONING KEYWAYS



①

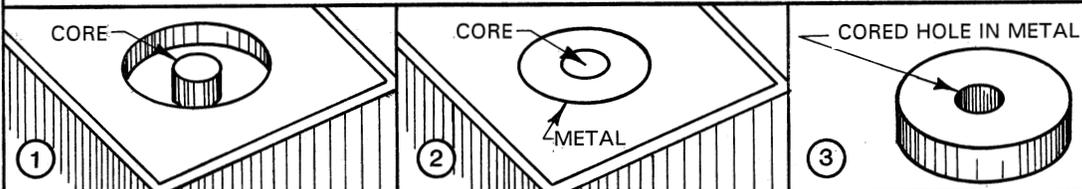
Keyways may be dimensioned directly.



②

Keyways may be dimensioned by reference to standard key nomenclature.

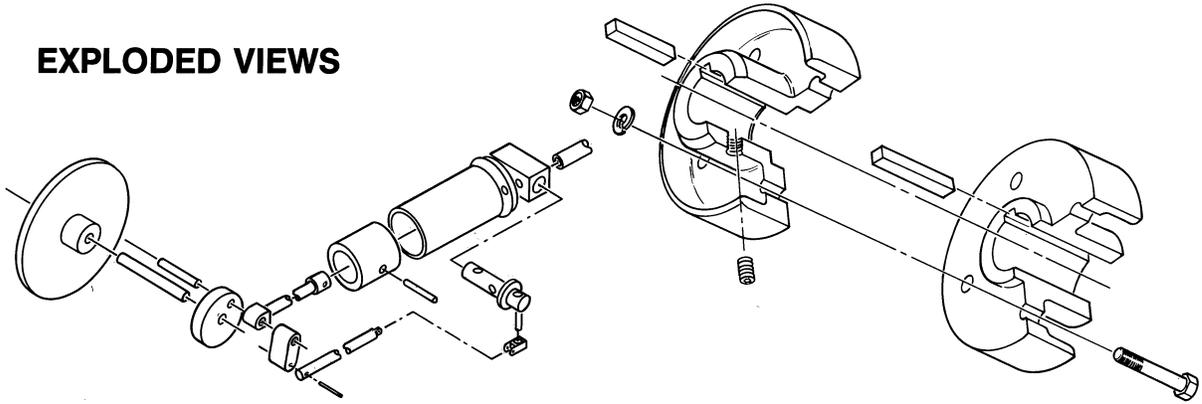
CORED HOLES AS MADE AT THE FOUNDRY



- ① A cored hole is made by placing a sand core in the mold.
- ② When the molten metal is poured, it flows around the core.
- ③ A cored hole is produced in the casting.

The term **cored hole** is a specific direction to the patternmaker and to the foundryman.

EXPLODED VIEWS



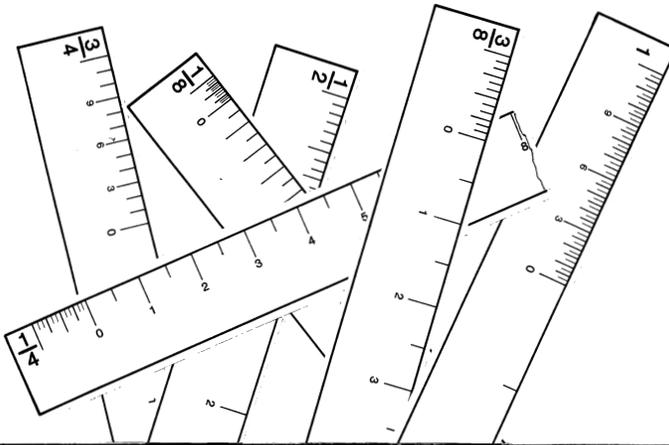
Exploded views are pictorial drawings showing all the parts of the item in their order of assembly. Generally, they are drawn on a 30° axis in isometric drawings.

STUDY THESE EXPLODED VIEWS

<p style="text-align: center;">FREEZE PLUG</p>	<p style="text-align: center;">FOUNTAIN PEN CLIP AND CAP</p>
<p>① Note the lines used to denote the assembly position for the plug.</p>	<p>② Exploded views are usually drawn on a 30° axis.</p>
<p style="text-align: center;">HALF LAP JOINT</p>	<p style="text-align: center;">WASHER ASSEMBLY</p>
<p>③ Joints for furniture construction are often drawn as exploded views.</p>	<p>④ "Do It Yourself" self-help books use exploded drawings for their instructions.</p>

UNIT 16

TESTS



Scale:		
FULL		1
FULL		2
$1/2" = 1"$		3
$1/2" = 1"$		4
$1/4" = 1"$		5
$1/4" = 1"$		6
$1/4" = 1"$		7
$1/8" = 1"$		8
$1/8" = 1"$		9
$1/8" = 1"$		10
$3/8" = 1"$		11
$3/8" = 1"$		12
$3/8" = 1"$		13
$3/4" = 1"$		14
$3/4" = 1"$		15

MEASURE TO THE CLOSEST 1/16" WITH A MECHANICAL ENGINEER'S SCALE.

SCALE:		
FULL		1
FULL		2
FULL		3
$1" = 10'$		4
$1" = 10"$		5
$1" = 20'$		6
$1" = 20"$		7
$1" = 30'$		8
$1" = 30"$		9
$1" = 40'$		10
$1" = 40"$		11
$1" = 50'$		12
$1" = 50"$		13
$1" = 50'$		14
$1" = 60'$		15

MEASURE TO THE CLOSEST 1/10" WITH A CIVIL ENGINEER'S SCALE.