

RULES FOR PLACEMENT OF DIMENSIONS

(See rules illustrated at top and right.)

- A. Always place the dimensions around the view that best shows the profile or contour of the surface to be dimensioned.
- B. Place the dimensions between the views and outside the "basic shape" whenever possible.
- C. Add the overall height (H), length (L), and depth (D) of the entire view as well as the H, L & D for every detail. (Objects with rounded ends made of arcs may be dimensioned from center line to center line of the arcs. No overall need be given.)
- D. Smaller detail dimensions should be placed nearest the view, with the larger overall dimensions placed farthest away.
- E. Dimensions should be placed so they can be read from the bottom or right side of the drawing. Never place dimensions to be read from the top or left side of the drawing.
- F. Whenever dimensions are placed "in-series", all dimension lines should be located on the same plane and one dimension in the series should be left out.
- G. If all "in-series" dimensions are added, one dimension should be considered a reference dimension and indicated by enclosing in parentheses, such as (.500). Reference dimensions are provided for information only, and are not necessary for the manufacture of the part.
- H. Place the number in the middle of the dimension line whenever possible.
- I. Numbers may be placed off-center (staggered) if necessary to avoid confusion.
- J. When dimensioning spaces of $1/2''$ or less, place the dimension lines outside of the extension line with the arrowheads pointing in. In some cases the dimension itself should be placed outside the extension lines.
- K. If in doubt as to whether a dimension is needed, it should be added. Unless a centerline is given to indicate the object is symmetrical, do not assume that the measurement of one feature is the same as that of another feature, which looks similar to it. It must be dimensioned also.
- L. Avoid placing dimensions on the view itself, unless it adds to the clarity of the dimensioning.
- M. Avoid dimensioning to hidden lines.
- N. Never duplicate a dimension.

PLACEMENT OF DIMENSIONS

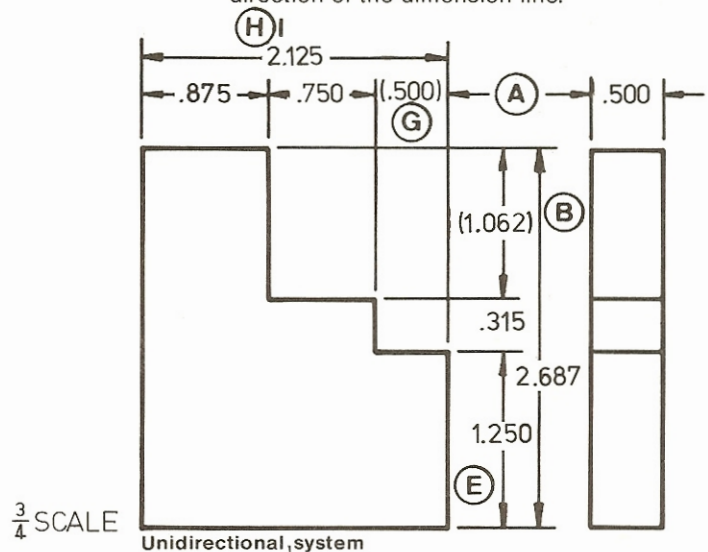
An engineering drawing must contain all the views, notes, and dimensions necessary to ensure correct fabrication of the part. Uniform practices for stating and interpreting dimensions on drawings have been established by ANSI and ISO (International Organization for Standardization).

If a drawing is to be of any value, it must be dimensioned properly according to these standards.

It should not be necessary for the manufacturer to scale a drawing or to calculate figures to determine a dimension. Nothing must be assumed.

Drawings created in the United States are dimensioned using fractions, decimals, or metrics. Normally one of two systems of dimensioning is used. They are:

- The **aligned system** - all dimensions are read from the bottom and right side and all numbers are in-line with (perpendicular to) the dimension lines.
- The **unidirectional system** - all dimensions are placed horizontally so they can be read from the bottom of the page, regardless of the direction of the dimension line.



PROPER PLACEMENT OF NUMBERS, LETTERS, & FRACTIONS

Before placing numerals within the dimension lines on a drawing, be sure that you are using a soft (H or 2H) lead with a well rounded point, and always use guidelines. The numbers should be centered on the dimension line. It is not necessary to use the inch symbol (") when dimensioning a drawing.

Letters and numbers are generally drawn $1/8''$ high.

Fractions are approximately $1/4''$ high.

Numbers that make up the fractions are approximately $3/32''$ in height.

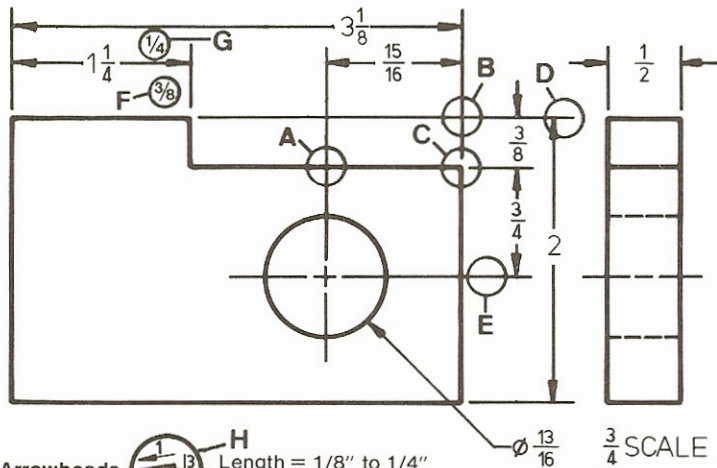
Be sure the fraction bar is drawn horizontally with instruments, and that the numbers do not touch the fraction bar.

Often drawings are dimensioned using the decimal inch system instead of using fractions. This system of measurement divides the inch into tenths instead of sixteenths, as in the fractional system. It is important for a drafter to know both systems, as well as metrics. In metric measurement the millimeter ($1/1000$ of a meter) is used to dimension drawings. A fraction/decimal/metric equivalent chart, like the one shown on the following page, will aid you in making any necessary conversions.

NAME: _____

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Arrowheads Length = 1/8'' to 1/4''
Width = 1/3 length

DIMENSIONING A DRAWING

Dimension lines are thin lines used to indicate the extent and direction of dimensions. They are drawn parallel to the feature they define, and normally end with uniformly made arrowheads that touch extension lines. Numerals that indicate the size of the measurement being dimensioned are placed within the dimension line.

Extension lines are thin lines that enable the extension of a surface of an object to a point outside the view for purposes of dimensioning.

Arrowheads are used on the ends of dimension (and leader) lines to point out where the dimension begins and ends. The filled-in black arrowhead serves to draw attention to the limits of a dimension. Arrowheads should always touch extension lines or touch the feature to which they refer.

RULES FOR DIMENSIONING A DRAWING

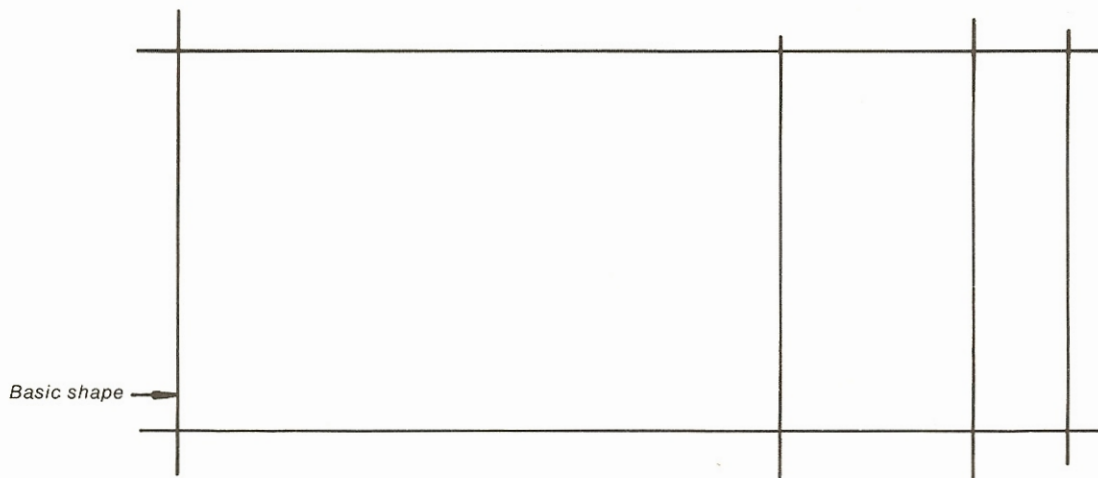
(See rules illustrated above.)

- A. Extension lines may cross visible object lines.
- B. Extension lines may cross other extension lines; they may not cross dimension lines.
- C. Always maintain a visible space of approximately 1/16'' between the object and the extension line.
- D. Extension lines should terminate 1/8'' past the last dimension line.
- E. Center lines often serve as extension lines when dimensioning round and symmetrical surfaces.
- F. Always leave a space of no less than 3/8'' between the object and the first dimension line.
- G. Dimension lines beyond the first should be no closer than 1/4'' to each other.
- H. Arrowheads are drawn 1/8'' to 1/4'' long, depending on the drawing size, and have a width equal to approximately 1/3 of the length.

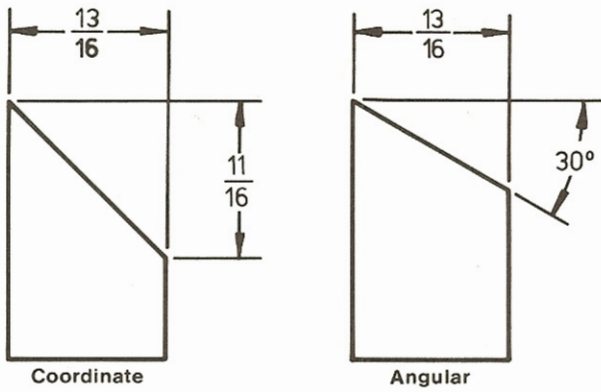
DECIMAL & METRIC EQUIVALENT OF FRACTIONS

Fraction	Decimal	Metric	Fraction	Decimal	Metric	Fraction	Decimal	Metric
1/64	.015625	.39688	23/64	.3593	9.12813	45/64	.7031	17.85938
1/32	.03125	.79375	3/8	.375	9.52500	23/32	.7187	18.25625
3/64	.046875	1.19063	25/64	.3906	9.92188	47/64	.7343	18.65313
1/16	.0625	1.58750	13/32	.4062	10.31875	3/4	.750	19.05000
5/64	.078125	1.98438	27/64	.4218	10.71563	49/64	.7656	19.44688
3/32	.09375	2.38125	7/16	.4375	11.11250	25/32	.7812	19.84375
7/64	.109375	2.77813	29/64	.4531	11.50938	51/64	.7968	20.24063
1/8	.125	3.17500	15/32	.4687	11.90625	13/16	.8125	20.63750
9/64	.140625	3.57188	31/64	.4843	12.30313	53/64	.8281	21.03438
5/32	.15625	3.9687	1/2	.500	12.70000	27/32	.8437	21.43125
11/64	.171875	4.36563	33/64	.5156	13.09688	55/64	.8593	21.821
3/16	.1875	4.76250	17/32	.5312	13.49375	7/8	.875	22.22500
13/64	.203125	5.15938	35/64	.5468	13.89063	57/64	.8906	22.62188
7/32	.21875	5.55625	9/16	.5625	14.28750	29/32	.9062	23.01875
15/64	.234375	5.95313	37/64	.5781	14.68438	59/64	.9218	23.41563
1/4	.250	6.35000	19/32	.5937	15.08125	15/16	.9375	23.81250
17/64	.2656	6.74688	39/64	.6093	15.47813	61/64	.9531	24.2093
9/32	.2812	7.14375	5/8	.625	15.87500	31/32	.9687	24.60625
19/64	.2968	7.54063	41/64	.6406	16.27188	63/64	.9843	25.00313
5/16	.3125	7.93750	21/32	.6562	16.66875	1.	1.0000	25.40000
21/64	.3281	8.33438	43/64	.6718	17.06563			
11/32	.3437	8.73125	11/16	.6875	17.46250			

Instructions: Redraw the view shown above to full size. Using the Unidirectional system and all proper dimensioning techniques, dimension the object by converting all fractions to 2-place decimals (.25 or 1.25). Use 1/8'' guidelines when drawing all numbers, neatly. (Do not add letters and circles.)



NAME: _____ DATE: _____ NO: _____



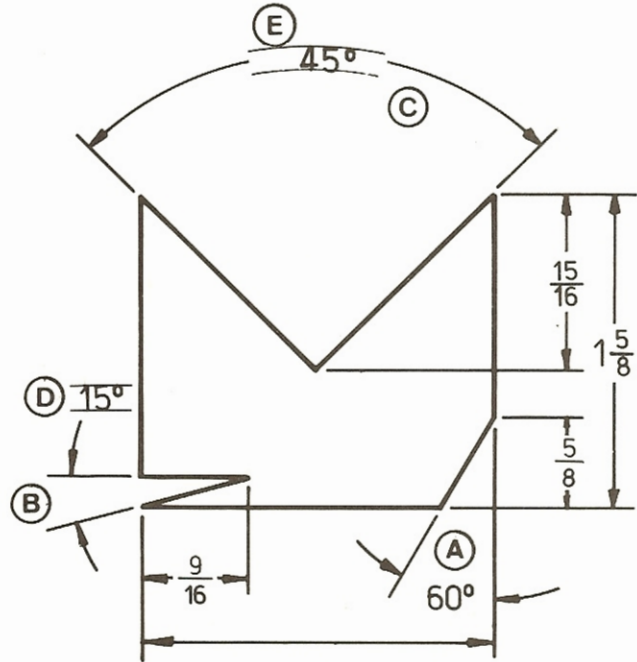
DIMENSIONING ANGLES & INCLINED SURFACES

Angles and inclined surfaces may be dimensioned in one of two ways as illustrated at left. The **coordinate** method is used where a high degree of accuracy is necessary and requires that both corners of the inclined surface be located. The **angular** method uses one dimension and the measurement of the angle, usually given in degrees (°), minutes (′), and seconds (″). On drawings where degrees are given alone, the number is always followed by the symbol (°).

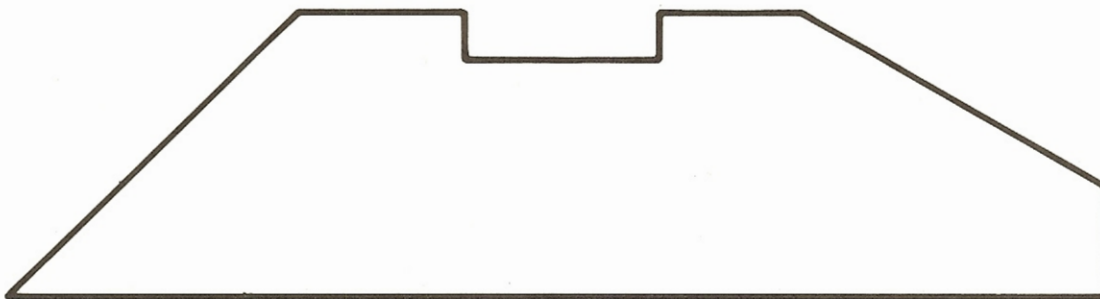
RULES FOR DIMENSIONING ANGLES & INCLINED SURFACES

(See rules illustrated at right.)

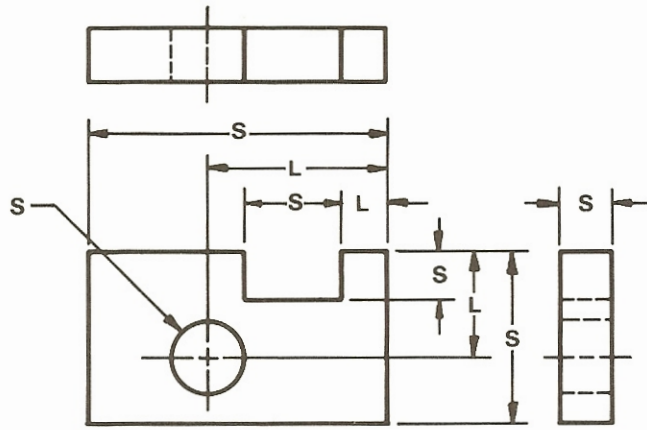
- A. Extend the surface of the angle with extension lines and place the numbers on the inside with the dimension lines and arrowheads on the outside, pointing in. Angles may be dimensioned inside the basic shape, or on the views, only if it serves to clarify the dimensioning.
- B. It may sometimes be necessary to place the numbers outside the extension line, also.
- C. Circular dimension lines should be drawn with the compass point placed at the vertex of the angle.
- D. Lettering is generally done on horizontal guide-lines.
- E. Circular guidelines may be used for large angles.



Instructions: Using the aligned system of dimensioning and all proper dimensioning techniques, measure and correctly dimension the object shown below using fractions. Use the angular system to dimension the angle shown at the left. Use the coordinate system for the angle at the right. Overall dimensions should be given above and to the right of the object.



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SIZE & LOCATION DIMENSIONS

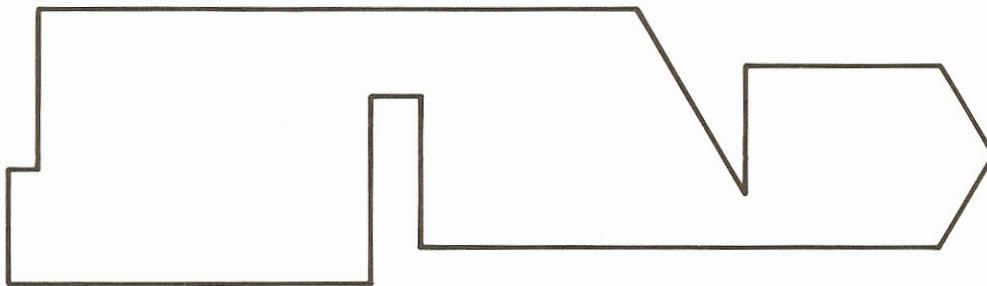
When dimensioning a drawing, always give the size (S) and location (L) dimension of every feature.

Size dimensions are those that give the size of the basic geometric shapes and forms. Location dimensions locate these basic shapes with respect to each other.

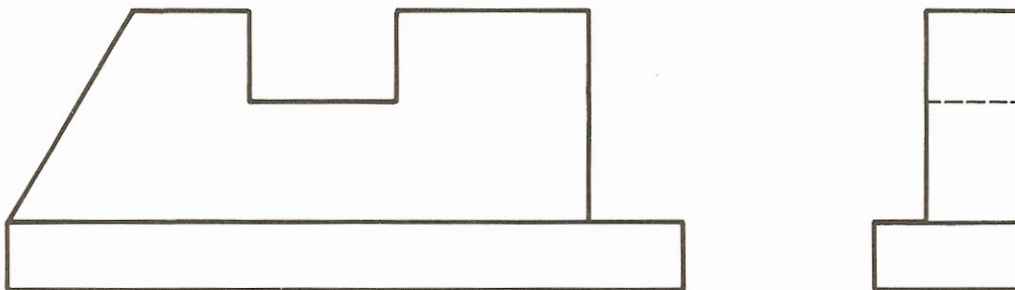
When placing these dimensions remember to always include the height (H), length (L) and depth (D) of every detail as well as the overall H, L & D of each view.

Instructions: Dimension the two objects shown below using proper line weight (thickness) and density (darkness). Create all dimensions lightly first. After rechecking for accuracy, darken all properly with a soft lead. Take all measurements directly from the drawings.

A. Dimension by the unidirectional system with fractions.



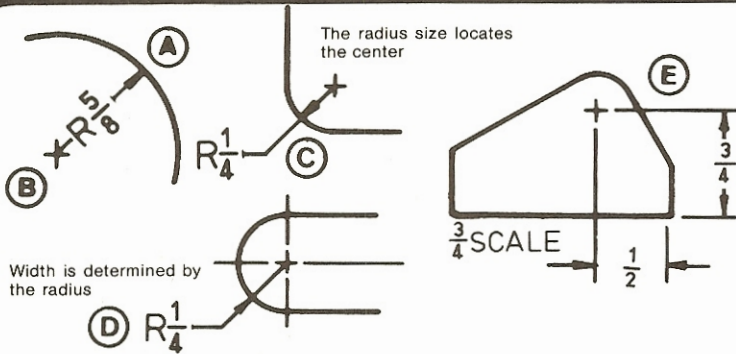
B. Dimension by the unidirectional system to three decimal places.



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RULES FOR DIMENSIONING ARCS

(See rules illustrated above and at right.)

- A. Whenever possible a dimension line should be drawn from the center point to the circumference of the arc. The arrowhead should touch the circumference and point out. A number indicating the size of the arc is placed within this dimension line.
- B. The center point of the arc should be indicated with two short lines (approx. $\frac{1}{8}$ ") crossing at a 90° angle.
- C. If space is limited, a leader line may be used in conjunction with the dimension line. The number is then moved outside the arc and centered at the end of the shoulder of the leader.
- D. If necessary, the arrowhead may also be placed outside the arc.
- E. Extension and dimension lines are used to locate the center of an arc.
- F. When a part has a number of radii the same size, a note may be used instead of dimensioning each radius separately.
- G. Rounded inside corners are known as fillets.
- H. Rounded outside corners are known as rounds, and like fillets, they are often dimensioned with notes.
- I. When a complete radius dimension line cannot be shown to-scale, because it is outside the drawing or interferes with another view, the dimension line may be foreshortened and shown with a short break or zig-zag in it.

LEADER LINES

Leader lines are thin inclined lines used to direct a dimension, note or symbol to the surface to be dimensioned.

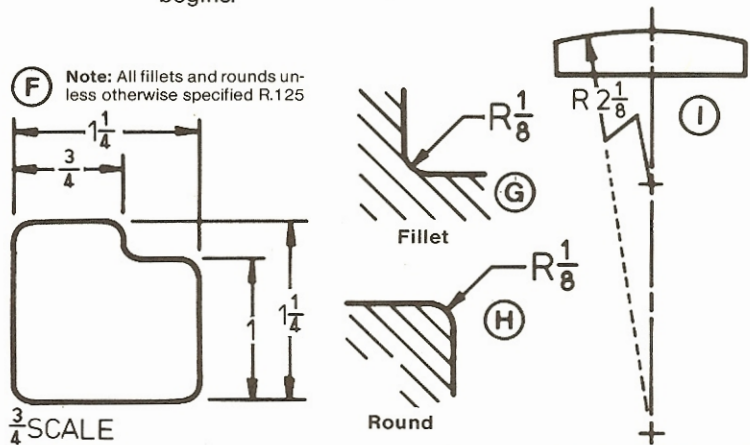
Leader lines can be drawn on any angle from 30° to 60° . They have a short horizontal shoulder that is approximately $\frac{1}{4}$ " long.

When leader lines are used to dimension a radius or diameter, the arrowhead should touch the circumference, and point to the midpoint of the arc or circle.

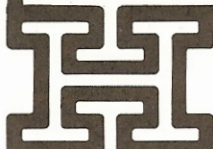
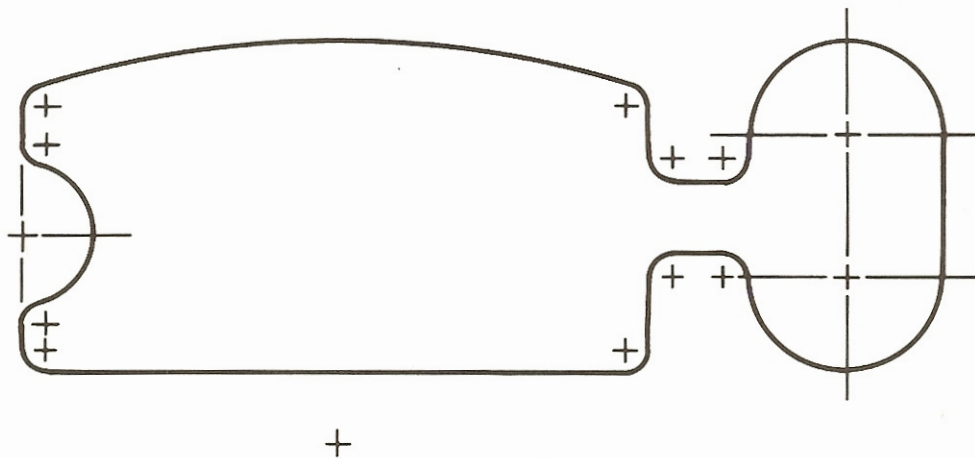
Never allow leader lines to cross dimension lines. They may cross visible object lines and extension lines.

DIMENSIONING ARCS

Arcs are dimensioned in terms of radii (R). They are dimensioned on the circular view in which they appear true shape. The capital letter R must always precede the dimension. Example R. 250. When drawing arcs, be sure that they flow smoothly into straight lines so you cannot see where the arc ends and the straight line begins.



Instructions: Using the unidirectional system and all proper dimensioning techniques, dimension the object below using fractions. Neatly letter all dimensions using $\frac{1}{8}$ " guidelines and $\frac{1}{4}$ " fractions. Draw all dimensions lightly first and darken only after rechecking for accuracy. Take all measurements directly from the drawing.



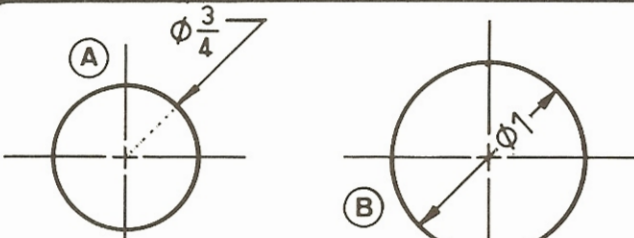
NAME: _____

DATE: _____

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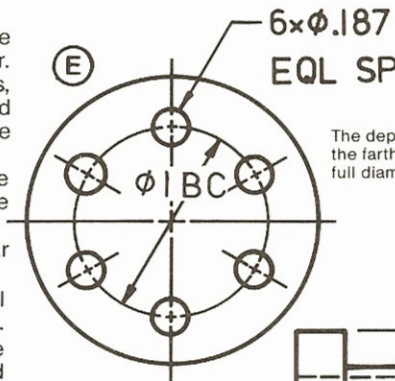
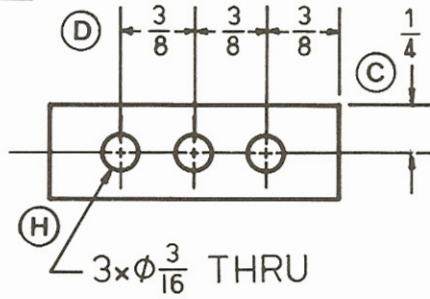
DIMENSIONING CIRCLES AND HOLES

Circles and holes are dimensioned in terms of diameter (ϕ). They are dimensioned on the circular view in which they appear true shape. The symbol ϕ must always precede the dimension. Example $\phi \frac{1}{2}$.

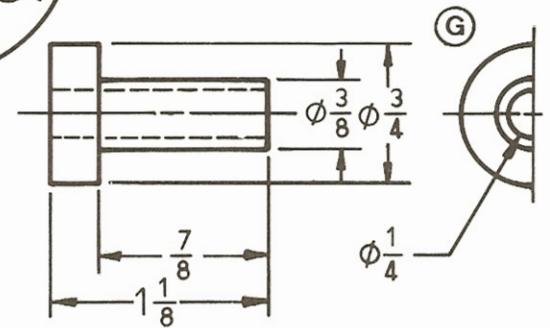
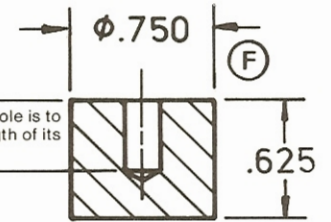


RULES FOR DIMENSIONING CIRCLES & HOLES (See rules illustrated above and at right.)

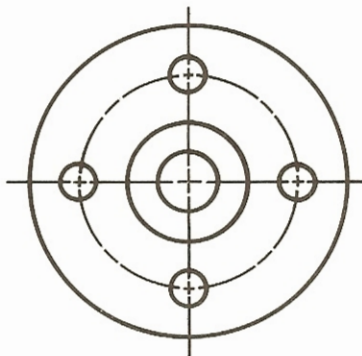
- A. Whenever possible, use a leader line to dimension a circle or hole, much like you would to dimension an arc. Be sure the arrowhead of the leader touches the circumference and points into the center point of the circle.
- B. The diameter may be indicated directly on the circle only if this serves to clarify the dimensioning.
- C. Always dimension a hole by locating its center in relation to a corner, if possible.
- D. If several circles are to be dimensioned, they may be located by dimensioning from center to center. Repetitive features or dimensions such as holes, and arcs may be specified by giving the required number of features and an "x" followed by the size dimension of the feature.
- E. Sometimes equally spaced (EQL SP) holes may be dimensioned on the same bolt circle (BC) with the use of a center line.
- F. Cylinders are to be dimensioned on the rectangular view.
- G. Partial views may be used to describe cylindrical objects only if both halves are identical (symmetrical).
- H. When dimensioning holes, along with giving the diameter, it may be necessary to give the depth and the number of holes required (in that order). The abbreviation THRU may be used to indicate a hole that passes all the way through an object, if the drawing does not make it clear.
- I. A hole that does not pass all the way through an object is referred to as a blind hole. The depth of a blind hole must be given. The symbol for depth is ∇ and must always precede the dimension.
- J. If only one hole is to be dimensioned, the number of holes required (REQD) need not be given.



The depth of a hole is to the farthest length of its full diameter.

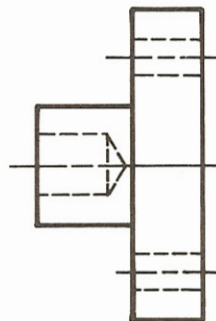


Instructions: Completely dimension the flange plate and drill stop shown below. Use the unidirectional system, and show all dimensions in decimals (to three decimal places). Be sure to observe all rules for dimensioning circles and arcs as stated above, and do all work as quickly, neatly and accurately as possible. Take all measurements directly from the views.

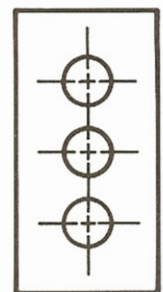


Front view

Flange plate



Side view



Drill stop

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HOLE CALLOUTS

When dimensioning machined holes on a drawing it is often necessary to supplement regular dimensions with notes. These notes, also referred to as **callouts**, should be brief and carefully written in a systematic order, so they will be subject to only one interpretation. Notes and callouts should always be lettered horizontally on a drawing using guidelines.

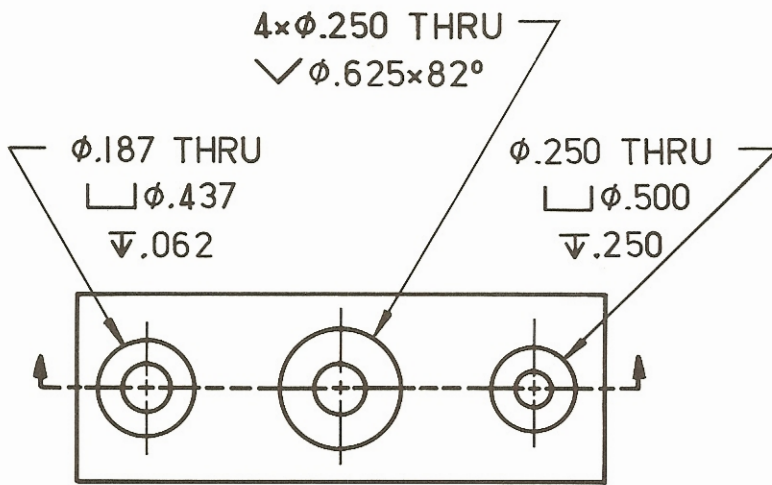
Notice the notes and symbols used to express the hole callouts shown here. The correct interpretations for these various notes are also given. Compare them.

In each case the thru hole is drilled first, therefore the diameter and depth of the thru hole is given first in the callout. The diameter and depth (or angle, in the case of a countersink) of the special characteristic (counterbore, spotface, etc.) is given next. Remember, if more than one hole is required, indicate this at the beginning of the callout by giving the required number of holes and an "x" followed by the diameter of the hole.

A **counterbore** is an enlarged cylindrical portion of a drilled hole, often found in metal. It is used to provide a recessed area in which to seat the head of a bolt or machine screw, below the surface of the object. The diameter and depth of the counterbore must be included in the hole callout. The symbol for a counterbore hole is \sqcup . Depth is indicated by the symbol ∇ .

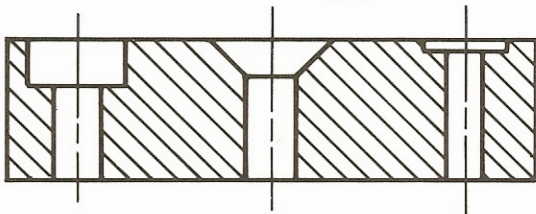
A **countersink** is an enlarged conical portion of a hole, often found in wood. It is used to provide a depression in which to seat the beveled head of a flathead screw, below the surface of the object. The diameter and angle of countersink must be given in a note. Though the angle of countersink is generally a standard 82°, to simplify drafting, it is usually drawn at 90°. The symbol for a countersink is \sphericalangle .

A **spotface** is a finished round depression on a rough surface used to provide a true and accurate bearing surface on which to seat the head of a bolt, washer, or nut. Though the diameter of a spotface must be given, it is not always necessary to give the depth, as this may be determined by the machinist. The symbol for a spotface is the same as that of a counterbore, \sqcup .



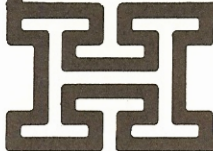
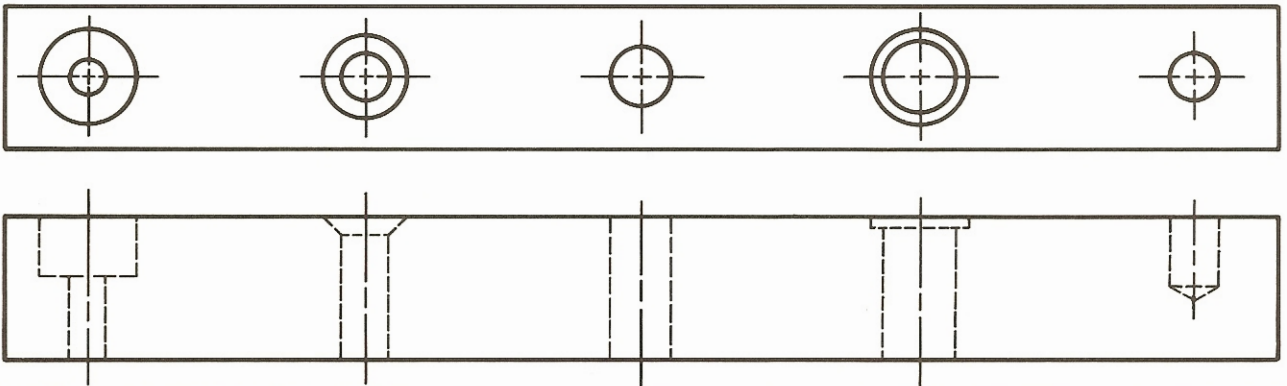
Explanation of above hole callouts:

- | | | |
|-----------------------|-----------------------|---------------------|
| Drill 1/4" THRU | 4 Holes Required | Drill 3/16" THRU |
| Counterbore 1/2" DIA. | Drill 1/4" THRU | Spotface 7/16" DIA. |
| 1/4" Deep | Countersink 5/8" DIA. | 1/16" Deep |
| | x 82° | |



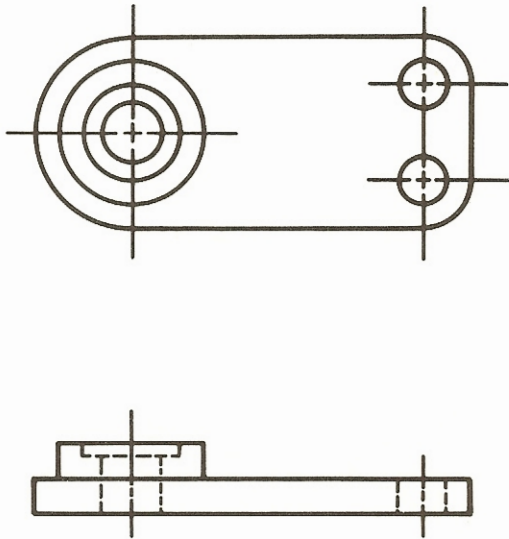
Full sectional view

Instructions: Correctly dimension the callouts for the holes shown below, using decimals. Letter the callouts using 1/8" guidelines and 1/8" spacing between the lines of the callout. Take the measurements directly from the top and front views. List the angle of countersink as a standard 82°. Do all work as neatly, quickly, and accurately as possible.



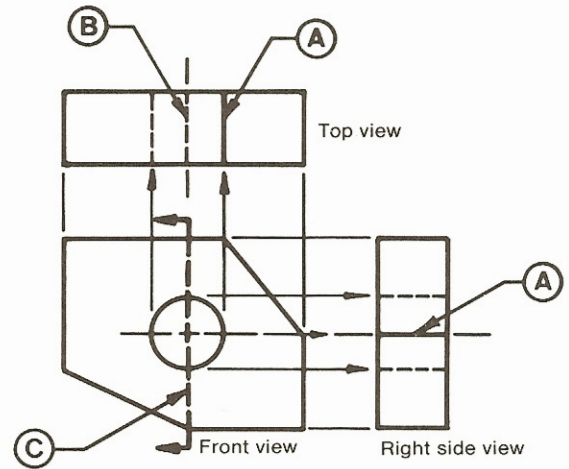
NAME: _____ DATE: _____ NO: _____

Instructions: Using all proper dimensioning and hole call-out techniques, dimension this object by the unidirectional system, using three place decimals. Take all measurements directly from the given views.

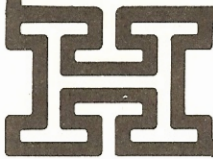
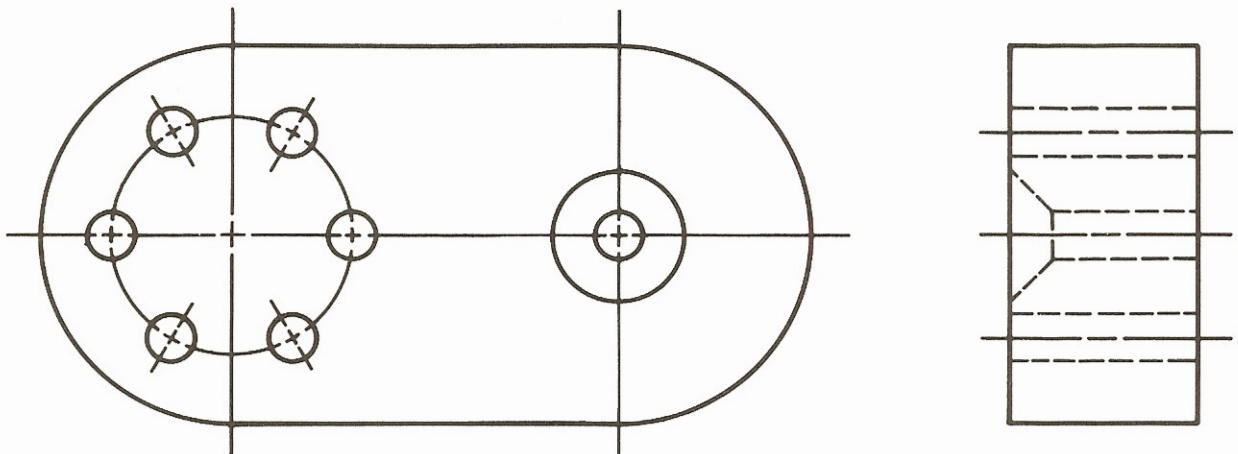


PRECEDENCE OF LINES

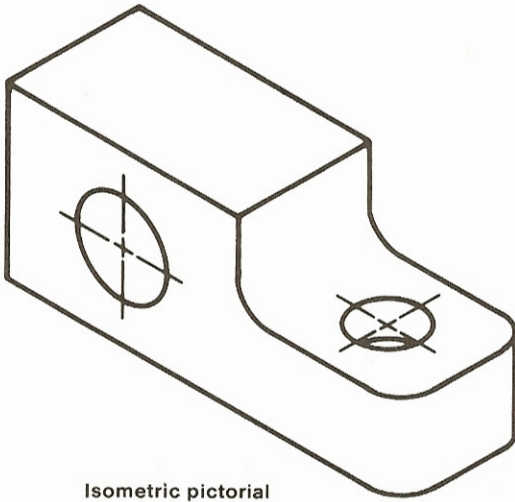
Whenever different types of lines in a view fall on the same plane, the most important line is shown. Visible object lines always take precedence over (cover up) all other lines (see A). Hidden lines always take precedence over center lines (see B). If a center line coincides with a cutting plane line, the cutting plane line is shown (see C).



Instructions: Completely dimension the object below as quickly, neatly and accurately as possible. Using the aligned system, show all dimensions as 3 place decimals, drawn 1/8" high. Create all dimensions lightly first. After rechecking for accuracy, darken all lines properly with a soft lead. Take all measurements directly from the drawing.



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Isometric pictorial

METRIC DIMENSIONING

The millimeter is the standard unit of linear measure used on metric engineering drawings. Both meter and millimeter units are used on metric architectural drawings.

Every metric drawing done in the United States should prominently display the word **METRIC**, somewhere within or near the title block. The units of measurement should also be indicated in a note somewhere on the drawing.

Dimension a metric drawing just as you would a regular inch drawing, using the same spacing and rules for placement of the dimensions.

RULES FOR METRIC DIMENSIONING

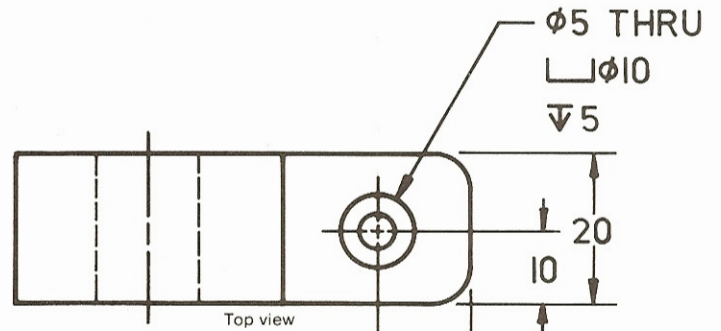
When a dimension is less than one millimeter, a zero is placed just to the left of the decimal point (0.627).

When a dimension is a whole number, it does not require a decimal point or a zero be shown after it (22 not 22.0).

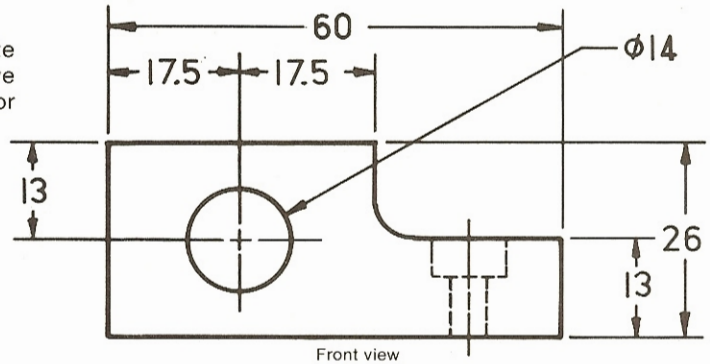
A space should be used instead of a comma to separate groups of three numbers, when writing numbers of five or more digits (36 035). A space is not necessary for groups of 4 digits or less (6035).

METRIC

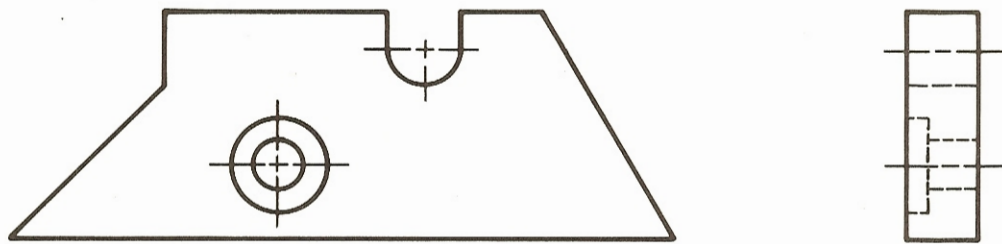
Note: Unless otherwise specified, dimensions are in millimeters.



Note: All fillets and rounds unless otherwise specified R5.



Instructions: Use a metric scale or conversion chart to dimension this object properly. Place the first dimension line 9mm away from the object and each succeeding dimension line 6mm away from each other. Take all measurements directly from the drawing. Place all dimensions neatly on the drawing with the use of 3mm guidelines for your letters and numbers, and 3mm spacing between lines of lettering.



NAME: _____ DATE: _____ NO: _____