Technical Sketching Worksheets

Why Is Sketching Important?

The process of engineering begins with an idea. The ability to communicate many technical ideas requires a translation from thoughts into pictures. A quick way to share an idea is through a technical sketch. Technical sketching is a tool used by engineers and inventors. If the idea turns out to be a good one, these first sketches are turned into detailed CAD drawings or solid models, which include measurements and other critical details. The initial sketches can be used to develop the first prototypes. The freehand sketch is the first step taken to turn an idea into reality.

Developing Proper Sketching Technique

All two-dimensional pictures can be broken into straight lines and curved lines. The next couple of exercises will help the novice to develop good sketching technique. We will start by practicing straight, parallel lines.

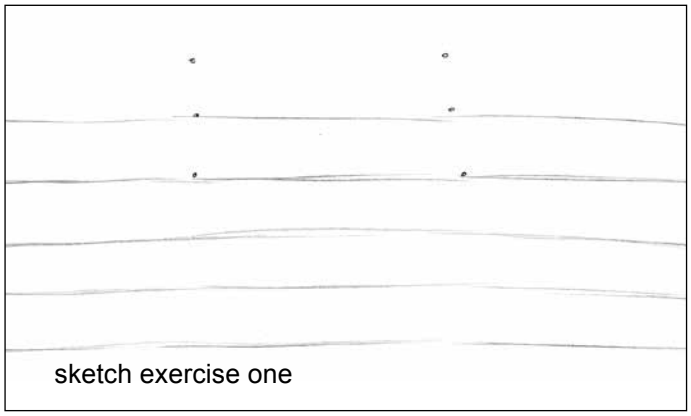
Things to remember:

1. Hold your pencil loosely.
2. Lock your wrist and move your whole arm as you sketch straight lines.
3. Guide the pencil with your eye by continually looking in the direction you would like the pencil to go.
4. Keep your lines light and consistent.

Straight lines

Sketch Exercise One

Begin by selecting a sharp pencil and a blank piece of paper. In this sketching exercise you will sketch straight, light lines. Keep your lines evenly spaced all the way down the paper. Initially, you may want to place a couple of light points that you can use as guides. Soon you will be sketching straight, light lines easily. Remember to look in the direction you would like the pencil to move. Keep all lines light. Hold the pencil loosely.



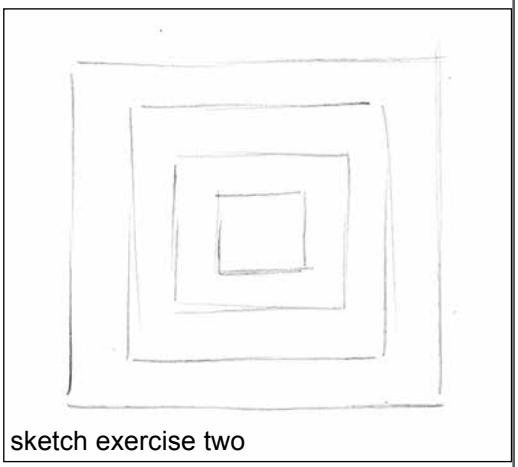
sketch exercise one

Sketching a Square

1. Sketch the top of the square, keeping the line parallel to the top of the paper.
2. Sketch the bottom of the square, keeping the line parallel to the first line.
3. Sketch the side, keeping the line perpendicular to the first two lines.
4. Sketch the last line, making sure that the last line is sketched in a position that makes both sides of the square equal.

Sketch Exercise Two

Begin with a blank sheet of scrap paper. Sketch a small square in the middle of the paper. Sketch another square around the first square. Maintain an equal distance between squares.



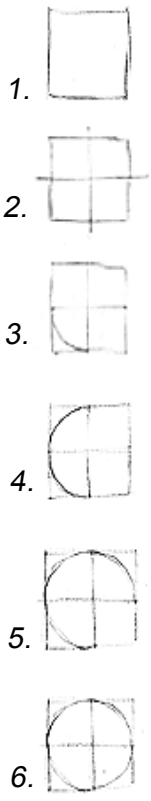
sketch exercise two

Sketching Proportionally Correct Curves and Circles

You do not have to be an artist to accurately and neatly lay out your ideas using technical sketching methods. A good example of layout is demonstrated at the right - laying out a circle. A circle fits perfectly into a square. In order to draw proportionally correct circles, use the following sequence:

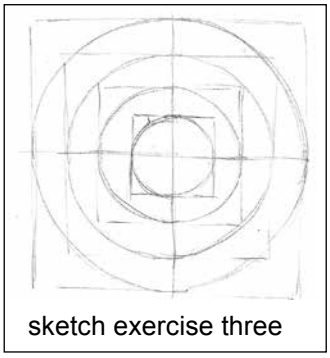
1. Begin by sketching a square.
2. Divide the square into four even areas.
3. - 6. Complete the four semi-circles.

Note: Remember to keep all of your lines light. Darken your lines when the sketch is correct.



Sketch exercise three

This sketching exercise is designed to give the beginner practice sketching straight and curved lines while keeping even spacing. Start by sketching a square in the middle of your paper. Then continue to add squares and circles until the paper is filled.

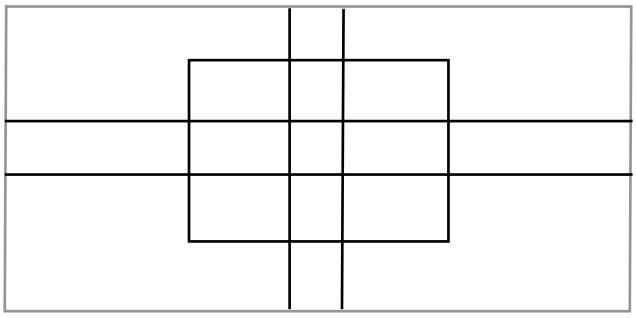

sketch exercise three

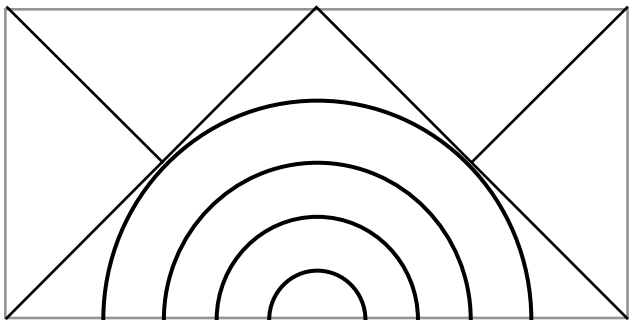
Additional Sketching Exercises

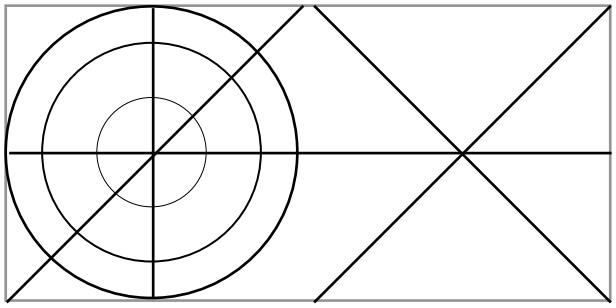
Use blank sheets of paper to sketch the shapes shown in the boxes below. You will need a sharp pencil. For extra practice, try sketching simple objects in the room.

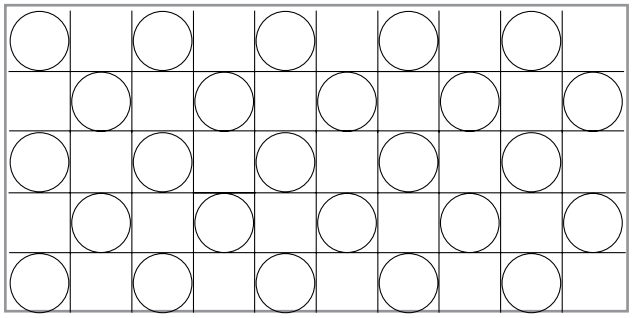
Things to remember:

1. Don't grip the pencil too tightly.
2. Keep developmental lines light.
3. Darken object lines when your drawing is complete.
4. Maintain proper proportion.
5. Keep your drawings neat.







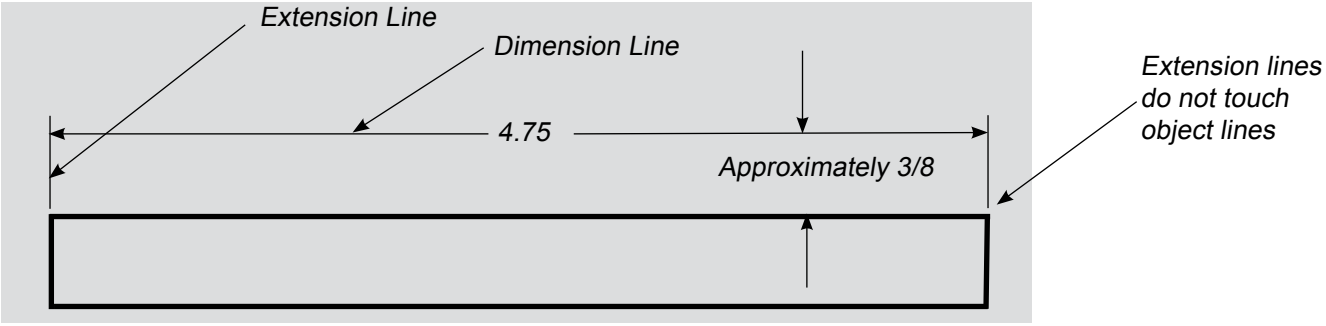


General Dimensioning Rules

Extension lines and dimension lines

-The first dimension line is spaced a minimum of 3/8” or 10 mm from the view and 1/4” or 6 mm for additional dimensions. All dimension, extension, and leader lines should be thin, sharp, and dark.

-Extension lines are started about 1/16” or 1 mm from the object and extend beyond the last dimension line about 1/8” or 2 mm.

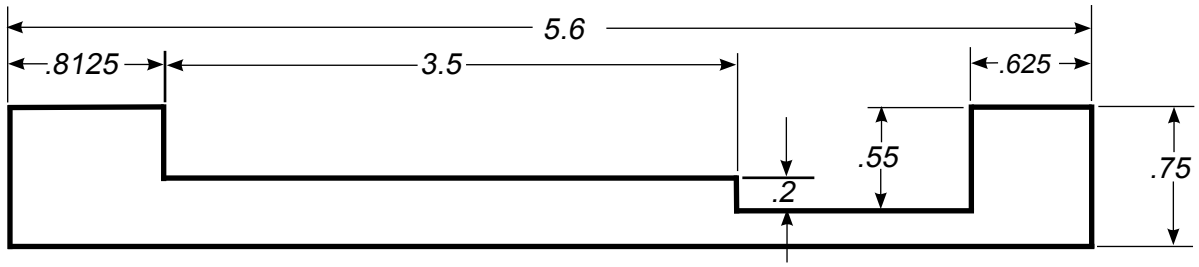


-When all of the dimension values are expressed in inches, the inch symbol (“) is omitted. For decimal values of less than 1 inch, omit the zero in front of the decimal point: eg. .25 or .875.

Dimensioning Practices

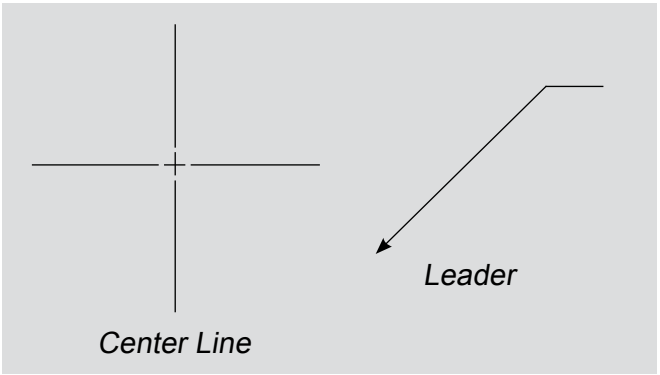
-Dimensions not required for manufacturing a part should be omitted.

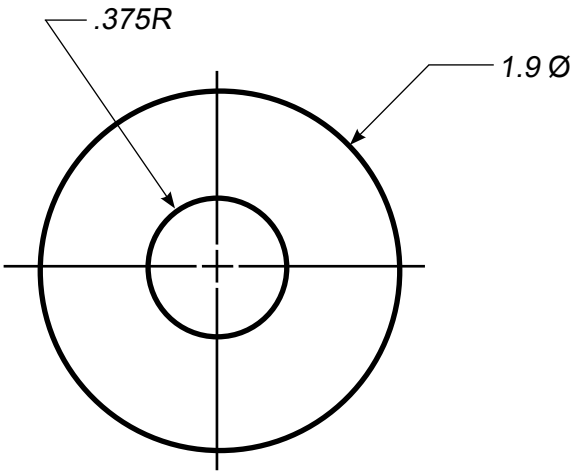
-Overall dimensions are placed outside the smaller dimensions. With the overall dimension given, one of the smaller distances is not dimensioned unless it is needed for reference, in which case it should be indicated by placing brackets around the value.



Leaders and Center Lines

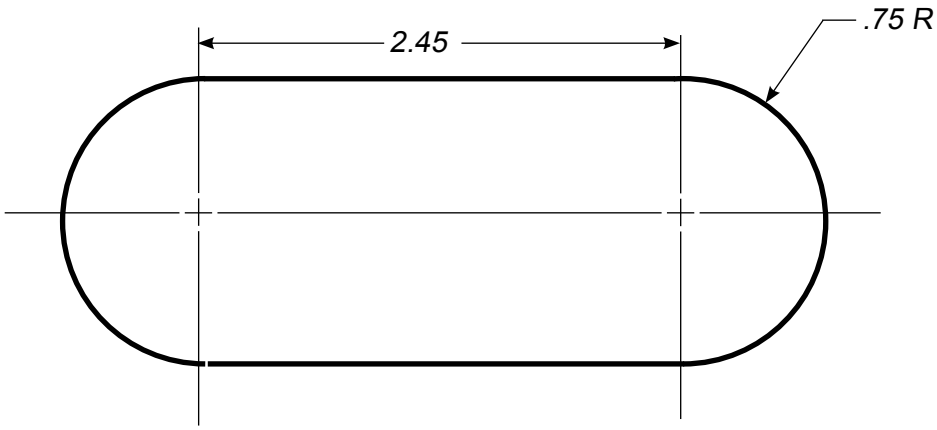
-When dimensioning circles, use a leader and center lines.
-Use an R to indicate radius dimensions, and a (Ø) symbol to indicate diameter dimensions.





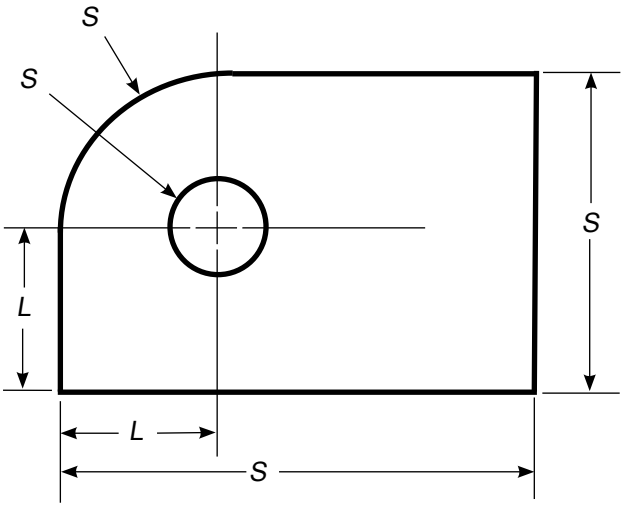
General Dimensioning Rules (continued)

-On circular end parts, the center-to-center dimension is given instead of an overall dimension.



Size and Location Dimensions

There are two types of dimensions: size dimensions and location dimensions. In the example below, the size dimensions are noted by the letter S and the location dimensions by the letter L.



For every rule there is an exception. The dimensioning rules given in this handout are introductory in nature and are not meant to replace an engineering drawing text.

Common Dimensioning Practices

-Avoid dimensioning to hidden lines.

-Place dimensions in views where the shape and location of the object is seen best.

-Avoid placing dimensions on the object if possible.

-Select one size for ALL dimensions/text.

-No more than two dimensions may be chained.

-All dimensions have a tolerance, either local (attached to the dimension), in a note, or general (tolerance block).

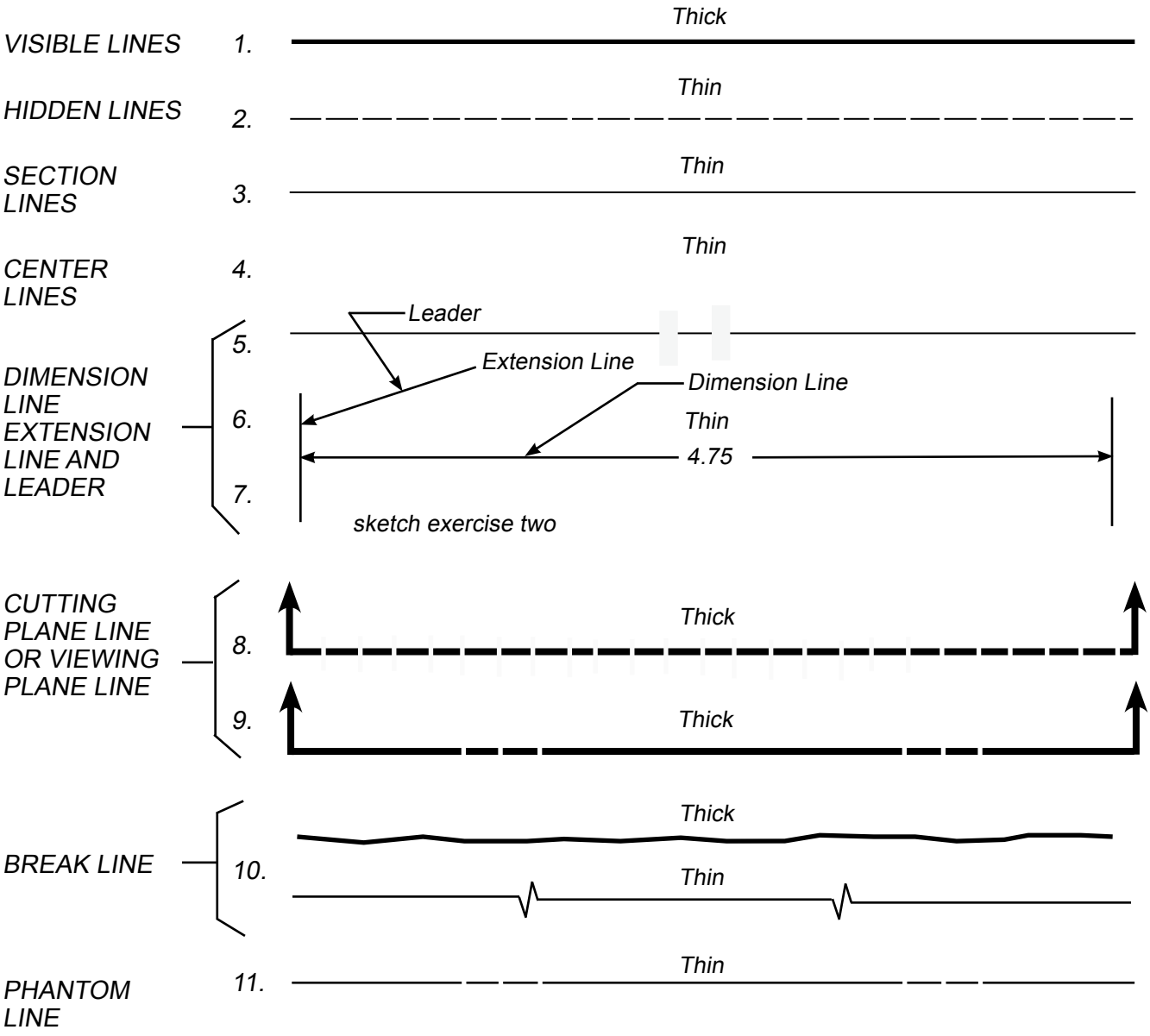
-Crossing of extension lines or dimension lines should be avoided if possible. Where such crossings are unavoidable, there should be no break in either of the lines. However, if extension lines cross dimension lines through the arrowheads, the extension line may be broken.

-Do not repeat dimensions on the same view or in other views.

-When a dimension figure has been changed so that it no longer agrees with the actual scaled distance on the drawing, it is customary to underline it with a wavy line or mark it NTS (not to scale).

Standard Line Conventions for Technical Drawing

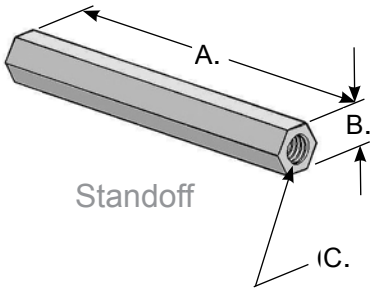
Technical drawing is a universal language. Engineers around the world use the same line conventions for all drawings. This allows them to share information quickly and accurately. Pictured below are standard line conventions used by engineers internationally. For more detailed information consult an engineering drawing text.



Precision Measurement

PRACTICE in MEASUREMENT

Use a caliper, micrometer, or steel rule tool to find the sizes of the following parts.
Round all answers to the the closest .005 of an inch.
Find the corresponding distance for letters A through L.



A. _____ **G.** _____

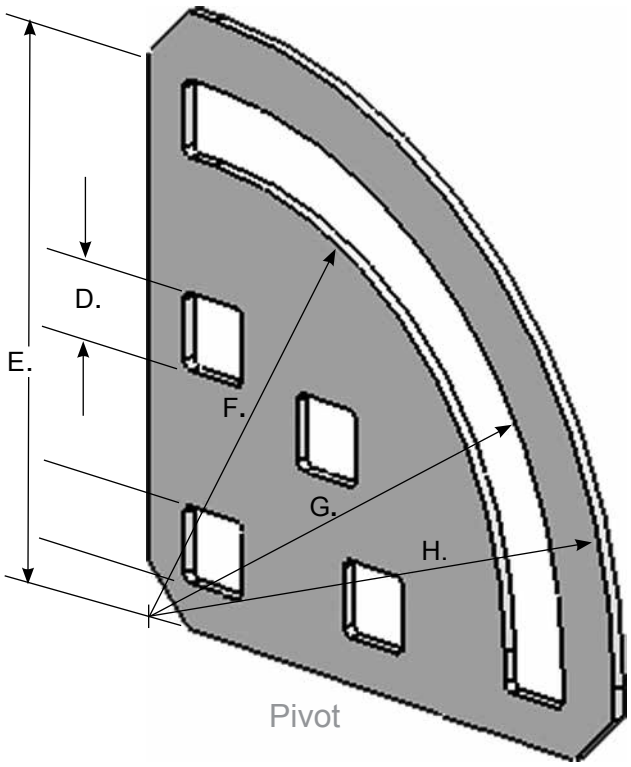
B. _____ **H.** _____

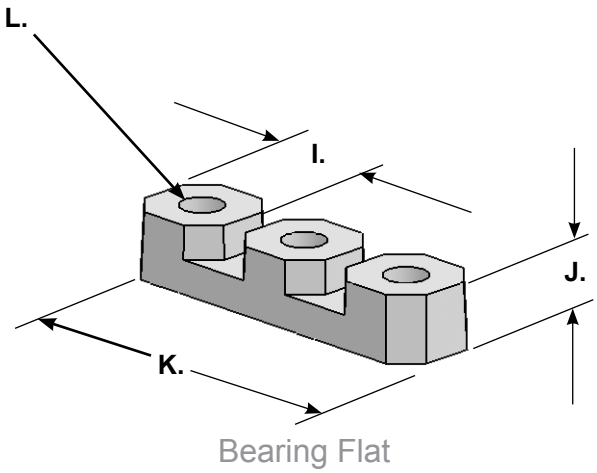
C. _____ **I.** _____

D. _____ **J.** _____

E. _____ **K.** _____

F. _____ **L.** _____





NAME

DATE

The Bearing Block

NAME

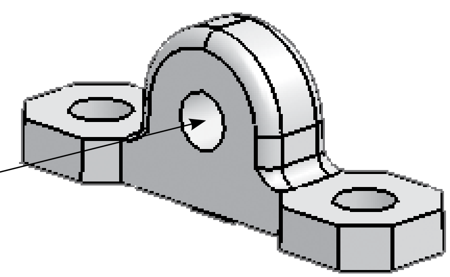
SKETCHING THE BEARING BLOCK

Use the empty boxes below to sketch the bearing block.
Use the actual physical piece or the supplied photo as a reference.

Use developmental lines and object lines, keep views aligned, maintain proper proportion, and keep the sketch neat.

Assessment Rubric	
Use developmental lines and object lines	1 pt
Views aligned	1 pt
Sketch proper proportion	1 pt
Sketch correct	2 pts
Sketch neat	2 pts
7- A 6- B 5- C 4- D	

Front



Bearing Block

TOP VIEW

DATE

FRONT VIEW

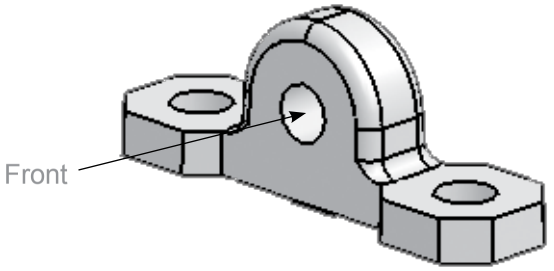
RIGHT VIEW

NAME

DIMENSIONING THE BEARING BLOCK

Sketch the bearing block in the area below. Use all of the allotted area to sketch your solution. After you complete the sketch, add dimensions to the drawing. Be sure to include center lines, hidden lines, and sizes of circles and arcs, as well as all appropriate notes.

Assessment Rubric	
Use developmental lines and object lines	1 pt
Measurements correct	2 pt
Sketch proper proportion	1 pt
Sketch dimensioned	
Size dimensions correct	2 pts
Location dimensions correct	2 pts
Extension lines correct	1 pt
Dimension lines correct	1 pt
10- A 9- B 8- C 7- D	



Bearing Block

DATE

The Gusset

NAME

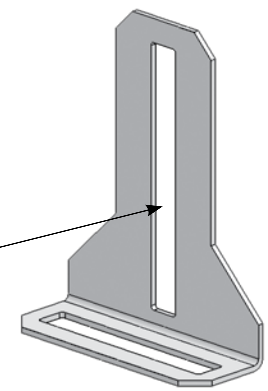
SKETCHING THE GUSSET

Use the empty boxes below to sketch the gusset.
Use the actual physical piece or the supplied photo as a reference.

Use developmental lines and object lines, keep views aligned, maintain proper proportion, and keep the sketch neat.

Assessment Rubric	
Use developmental lines and object lines	1 pt
Views aligned	1 pt
Sketch proper proportion	1 pt
Sketch correct	2 pts
Sketch neat	2 pts

7- A   6- B   5- C   4- D



TOP VIEW

DATE

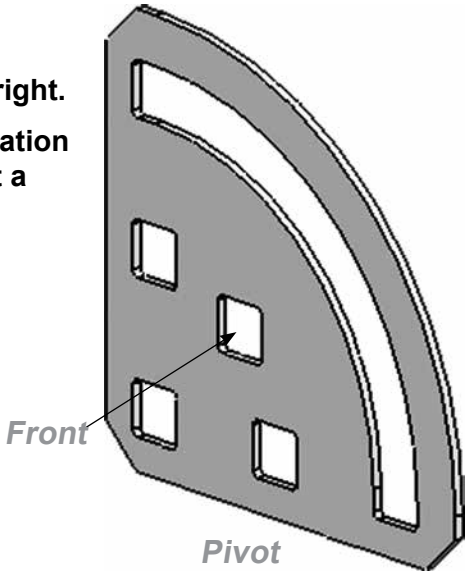
FRONT VIEW

RIGHT VIEW

Dimensioning the Vex Pivot Part

Sketch the front view of the Vex pivot part shown at the right.

Use a caliper, micrometer, or rule to find the size and location of all geometry used to lay out the Vex pivot part. Layout a properly proportioned sketch of the Vex pivot part. Dimension the front view sketch of the pivot part.



Assessment Rubric	
Use developmental lines and object lines	1 pt
Measurements correct	2 pt
Sketch proper proportion	1 pt
Sketch dimensioned	
Size dimensions correct	2 pts
Location dimensions correct	2 pts
Extension lines correct	1 pt
Dimension lines correct	1 pt

10- A 9- B 8- C 7- D

Vex Pivot Part - sketched approximately 3 to 1 scale

NAME

DATE

The Plus Gusset

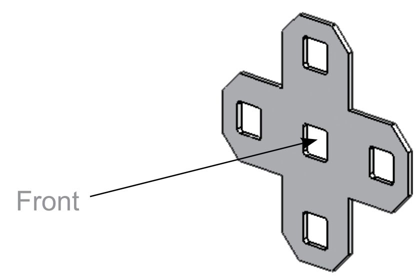
NAME

SKETCHING THE Plus Gusset

Use the empty boxes below to sketch the plus gusset.
Use the actual physical piece or the supplied photo as a reference.

Use developmental lines and object lines to lay out the plus gusset. Because of its thickness, you are only required to sketch the front view. Maintain proper proportion and keep the sketch neat.

Assessment Rubric	
Use developmental lines	1 pt
Straight dark object lines	1 pt
Sketch proper proportion	1 pt
Sketch correct	2 pts
Sketch neat	2 pts
7- A 6- B 5- C 4- D	



Plus Gusset

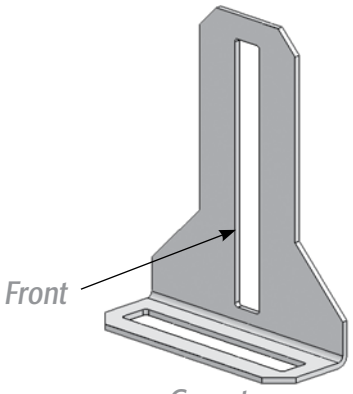
FRONT VIEW

DATE

Dimensioning the Vex Gusset

Sketch the front and side view of the Vex gusset shown at the right.
Use a caliper, micrometer, or rule to find the size and location of all geometry used to layout the gusset pictured at the right.
Layout a properly proportioned sketch of the gusset.
Dimension both views of the gusset.

Assessment Rubric	
Use developmental lines and object lines	1 pt
Measurements correct	2 pts
Sketch proper proportion	1 pt
Sketch dimensioned	
Size dimensions correct	2 pts
Location dimensions correct	2 pts
Extension lines correct	1 pt
Dimension lines correct	1 pt
10- A 9- B 8- C 7- D	



Front

Right Side

Vex Gusset - sketched approximately 2 to 1 scale

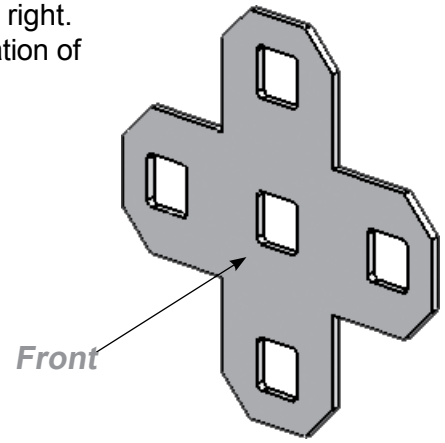
NAME

DATE

Dimensioning the Vex Plus Gusset

Sketch the front view of the Vex plus gusset shown at the right. Use a caliper, micrometer, or rule to find the size and location of all geometry used to lay out the Vex plus gusset.

Assessment Rubric	
Use developmental lines and object lines	1 pt
Measurements correct	2 pt
Sketch proper proportion	1 pt
Sketch dimensioned	
Size dimensions correct	2 pts
Location dimensions correct	2 pts
Extension lines correct	1 pt
Dimension lines correct	1 pt
10- A 9- B 8- C 7- D	



Plus Gusset

Vex Plus Gusset - sketched approximately 3 to 1 scale

Pattern Development

A pattern development of an object is a representation where the surface of the object is stretched out on a plane. In the sheet metal trade, a development is referred to as a pattern or a stretch-out.
Figure 1. When designing with the Vex Robotics kits, you may need to create your own pattern developments to complete an attachment or gripper for your robot.

Patterns can be made out of paper, cardboard, plastic, and sheet metal. Paper or cardboard models should be made before you make your piece out of sheet metal. The final fit and accuracy of the part will depend on the accuracy of the measurement and layout of your drawing.

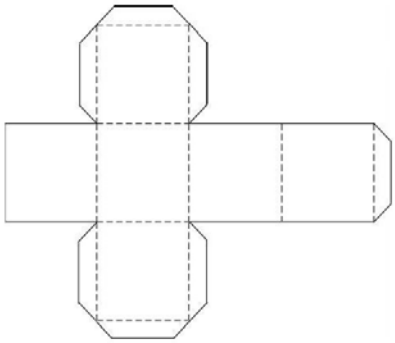


Figure 1 Pictured above is an example of a pattern development. The dashed lines represent fold lines

Finishing/Joining Pattern Developments

There are many ways that your pattern development can be joined. How you fasten your pattern development together will be determined by the material that you are using. Pattern developments can be folded, soldered, riveted, or bolted together. Figure 2 (below) provides examples of the types of joints commonly used on sheet metal.

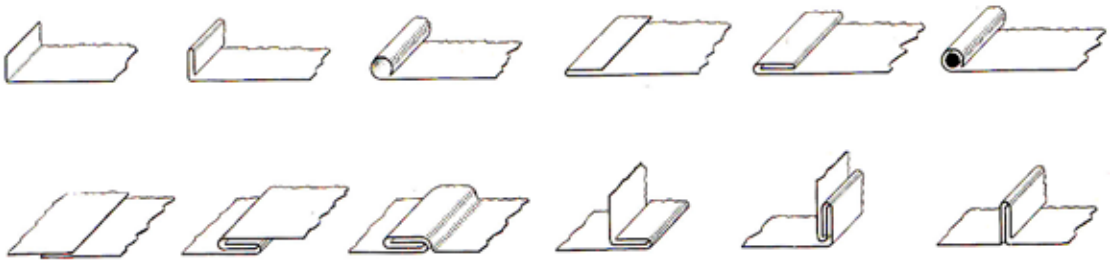


Figure 2 Shows examples of joints commonly used with sheetmetal

Bend Allowance

When planning pattern developments, it is necessary to plan for a bend allowance. The bend allowance is the material that will be stretched when the fold is made (Figure 3). The material allowed for the corners is called the bend allowance. Bend allowance is calculated with variables for the smallest radius of the bend (R), the thickness of the metal (T), and the angle of the bend (B).

BA = (.01745 R + .0078 T)B

The total length of the pattern = C + BA + D

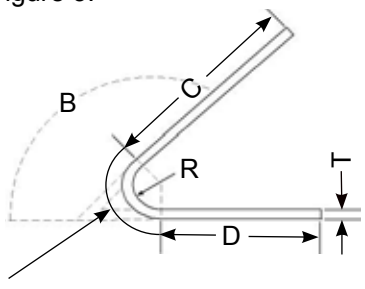
In Figure 3. given R = 5/16”; T = .040; B = 135 degrees

BA = [(.01745*.312) + (.0078*.040)]135

= (.0054 + .0003)135

.....= .7695”

Figure 3.



Pictorial Sketches

Isometric Pictorial - A drawing where length, width, and height are represented by lines 120 degrees apart, with all measurements in the same scale. When sketching in isometric, begin with the isometric axis (Figure 1). Next, make an isometric cube (Figure 2) with the same proportions as the object that you are sketching. Use the crating technique to complete the sketch.

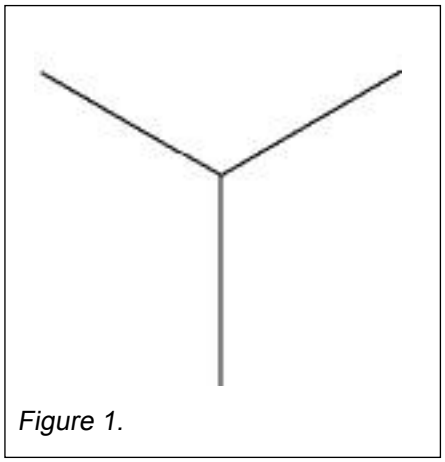


Figure 1.

Isometric Axis

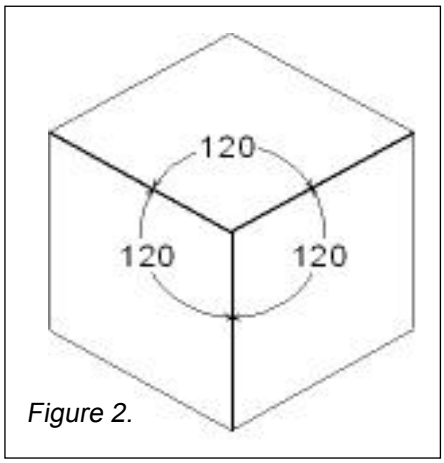


Figure 2.

Isometric Cube

Oblique Pictorials - There are two types of oblique pictorials: cabinet and cavalier. Cabinet oblique pictorial views (Figure 3.) are commonly used to quickly sketch ideas. The height and length axes are at a 90° angle and the width axis is usually at 45° to horizontal. Height and length dimensions are actual size but the width dimension is divided in half.

Cavalier oblique pictorial views (Figure 4.) are commonly used for drawing thin objects that do not have a lot of width. The height and length axes are at a 90° angle and the width axis is usually at 45° to horizontal. Height, width, and length dimensions are actual size.

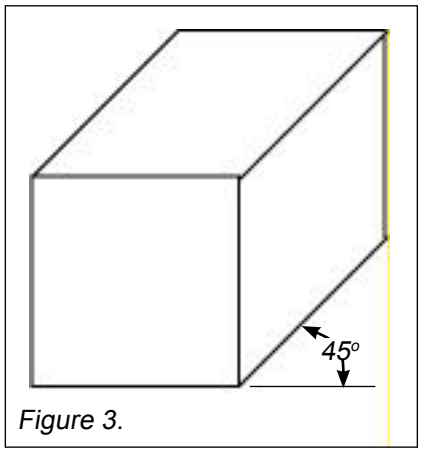


Figure 3.

Cavalier Oblique Pictorial Cube

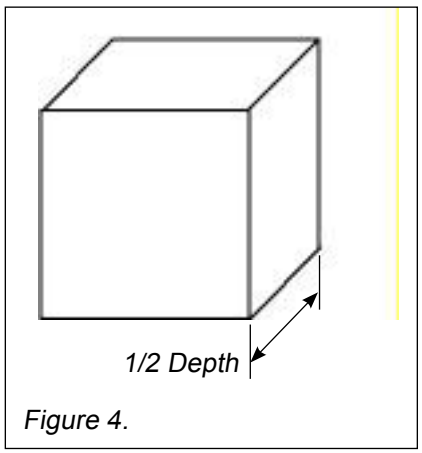


Figure 4.

Cabinet Oblique Pictorial Cube

Screw Head Types

1. *Hex Head Screw- Hex head screws can take a lot of torque and can be driven in and out with a socket type wrench.*
2. *Button head Screw – Button head screws are round at the top so that they do not catch on anything.*
3. *Flathead Screw – Flathead screws have tapers that guide.*
4. *Set Screws – Set screws are case hardened and are used to fasten pulleys and collars on shafts.*
5. *Allen Head Screws – Allen head screws have more torquing power and are recessed into a counter bored hole.*
6. *Pan Head Screws – Pan head screws have a small flat with a round top that can be slightly recessed into a counter bored hole.*

Nuts/Fasteners

7. *Nylon Insert Lock Nuts – or self-locking nuts, eliminate the needs for washers.*
8. *Wing Nuts – named for the two flat wings and are used when the nut has to be turned by the thumb and the forefinger.*
9. *Weld Nuts – These are specialty type nuts used to attach parts to a frame.*
10. *Kep Lock Nuts – These nuts have a greater holding power and reduce assembly time.*
11. *Coupling Nuts – These nuts are used to provide clearance between parts.*

Socket and Screw Head Drives

Drives are the slots, grooves, and holes used on the screw heads. Two different types of drives are socket head drives and screw head drives.

12. *Slotted – A flathead screwdriver is used to insert the screw.*
13. *Phillips – A phillips head screwdriver is used to insert the screw. A phillips head drive is easier to locate than a standard driver.*
14. *Hex – Hex drives have an external hex shape and can also take the large amount of torque that is generated by a socket wrench.*

15 *Socket Head Drives - can take a large amount of torque. They have an internal hex shape.*

16 *Phillips/Slotted – This versatile drive lets you use either a phillips or a slotted drive.*

Directions

Sketch and label the appropriate views of the nuts and bolts below.

Assessment Rubric

Use developmental lines	1 pt
Use object lines	1 pt
Sketch proper proportion	1 pt
Sketch correct	2 pts
Sketch neat	2 pts

7- A 6- B 5- C 4- D