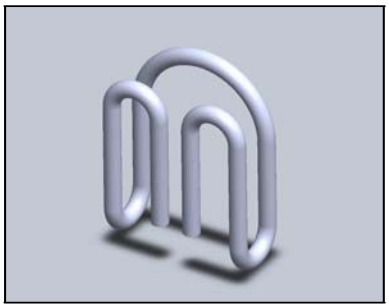
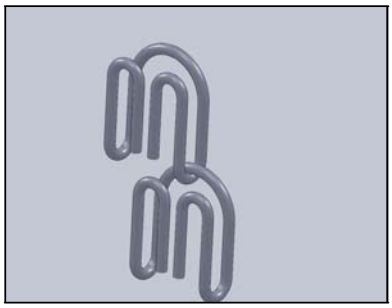
Metal Puzzle





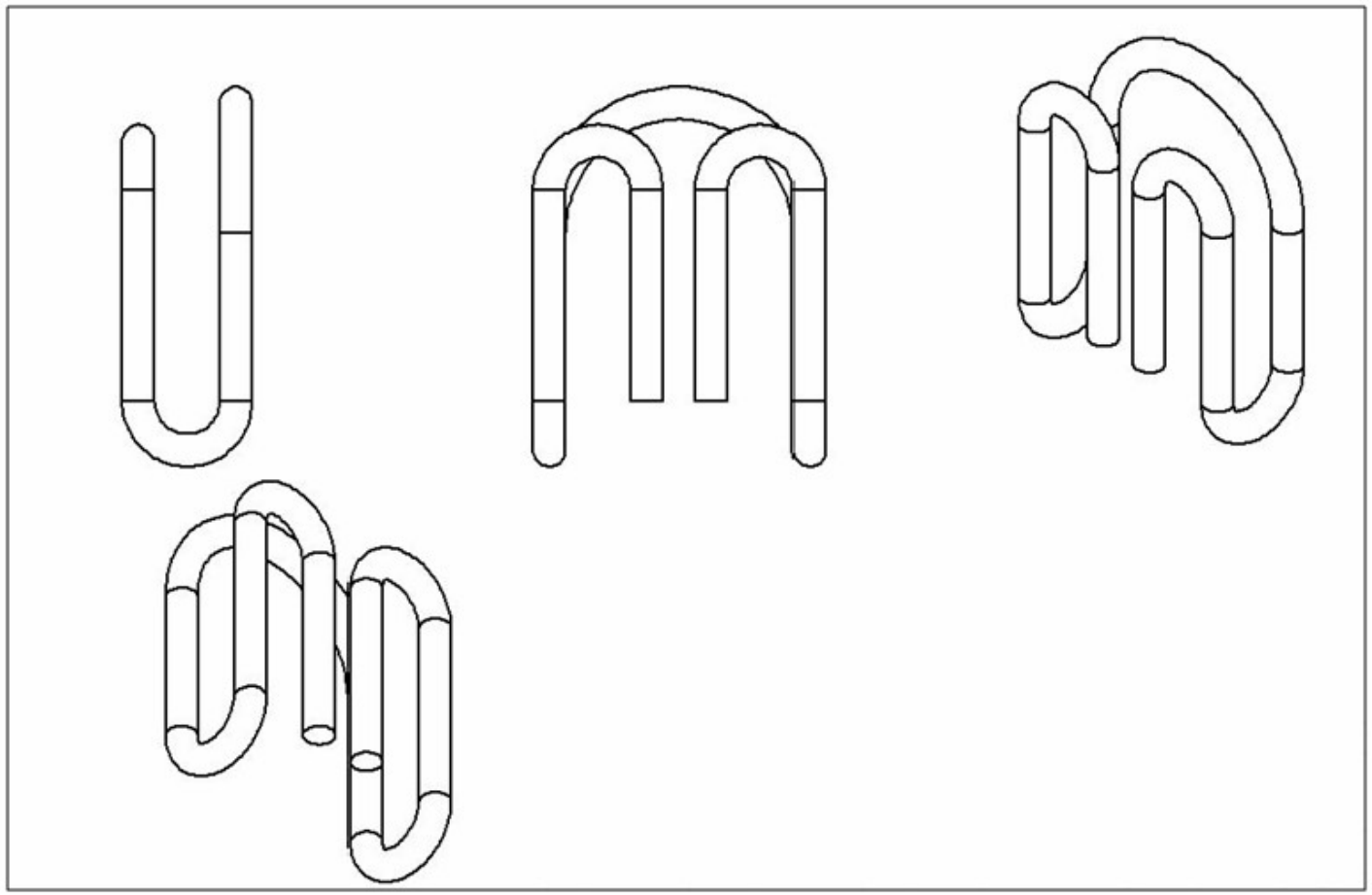
Equipment

A. Hacksaw
B. Tape Measure
C. Marker
D. Self Locking Pliers
E. Bench Grinder
F. Bench Vice
G. Two 3/8” Diameter Dies
H. One 1 1/4” Diameter Die
I. Safety Glasses
J. Bar Clamp

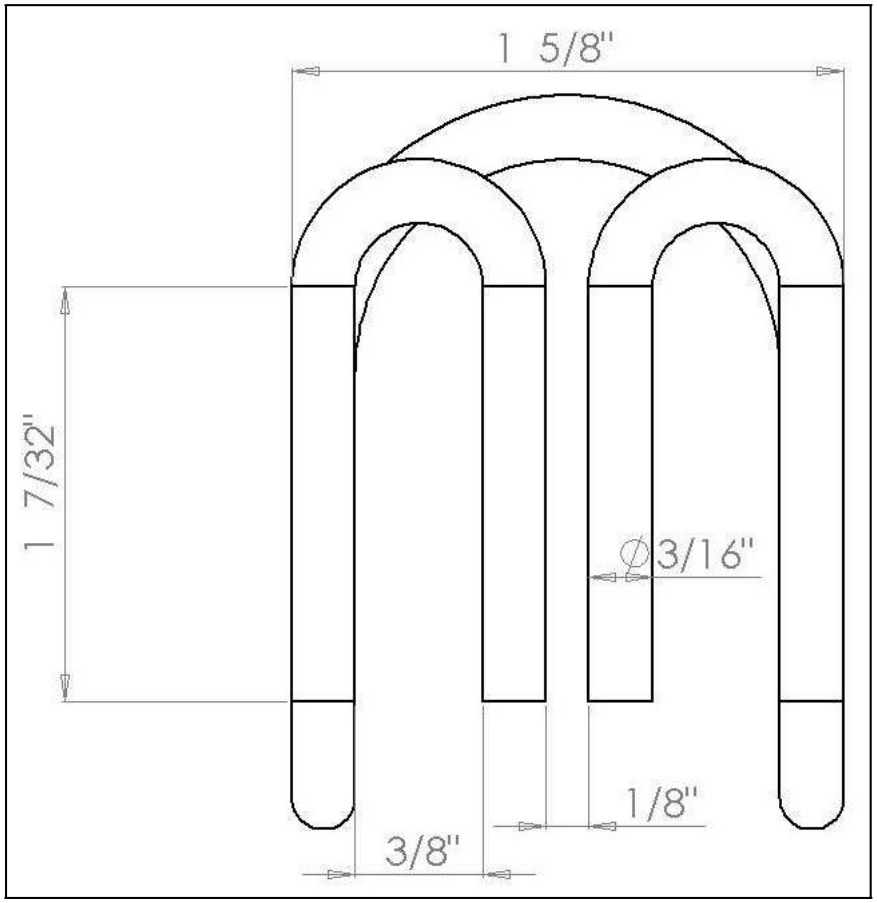
Materials

A. 12 13/16” x 3/16” Steel Rod

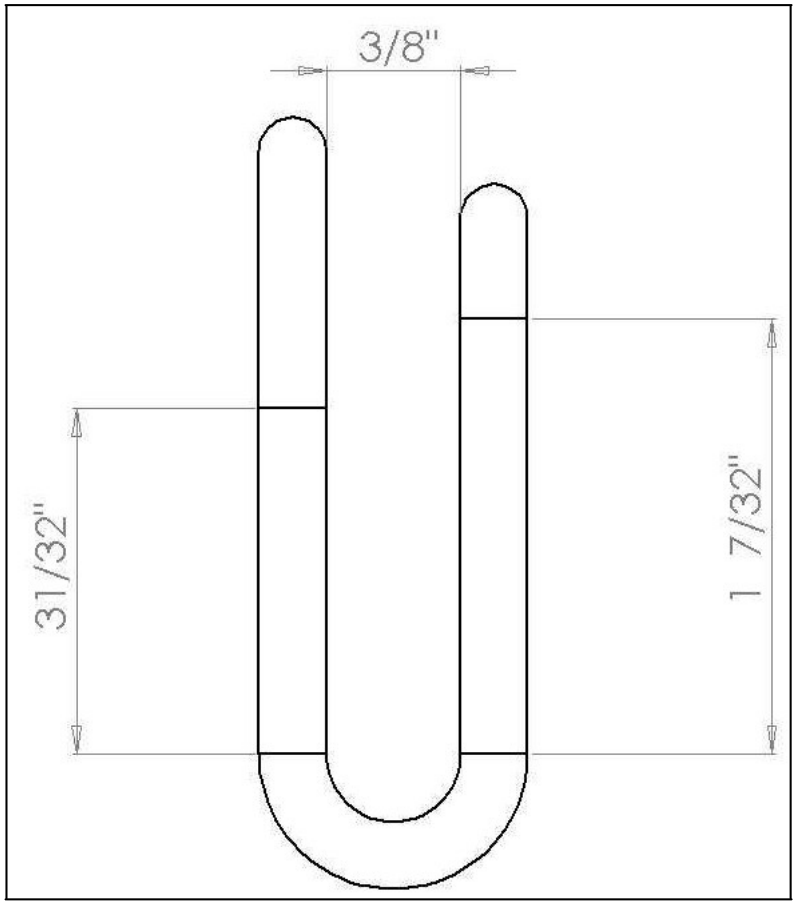
Drawing 1: Puzzle Piece



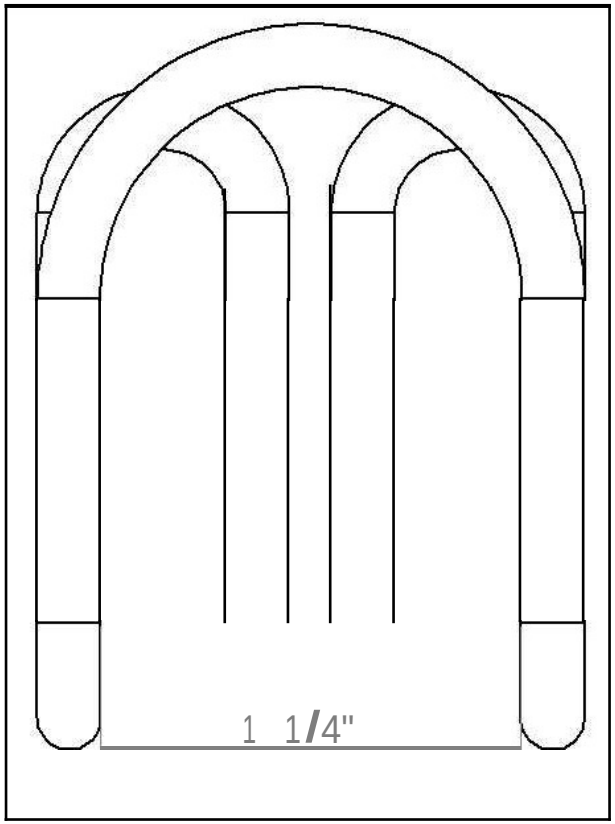
Drawing2: Puzzle Front



Drawing3: Puzzle Side



Drawing 4: Puzzle Back



Beginning Note: This project involves making two identical pieces. The procedure outlines how to complete one piece, but both pieces can be made simultaneously.

Step 1: Lay out and cut a 12 13/16" section of **3/16" Steel Rod** using a **Tape Measure**, **Marker**, **Bench Vice**, and **Hacksaw**.

A. Using the **Tape Measure** make a tiny mark on the of **3/16" Steel Rod** 12 13/16" from one end using a **Marker**.

B. Clamp the rod in the **Bench Vice** with the mark about 1/4" to 1/2" away from the edge of the vice as shown in Figure 1(2).

Note: The farther away the mark is from the vice, the more the rod will bend with each stroke of the **Hacksaw,** making it hard to cut. The rod also might deform.

C. Align the **Hacksaw** blade on the side of the line opposite of the desired piece.

Note: Due to the width of the saw blade, if you cut down the center of the drawn line, your piece will be half the blade's width shorter than what you measured.

D. The **Hacksaw** blade is designed to cut in one direction only, most of the time it is set up to cut when the user pulls the saw towards them. To cut the rod, push and pull the saw across the rod. Relax on the push stoke and put a small amount of downward pressure on the pull stroke. Once the blade is almost all the way through the rod, slow the sawing action down and continue to cut the rod through.

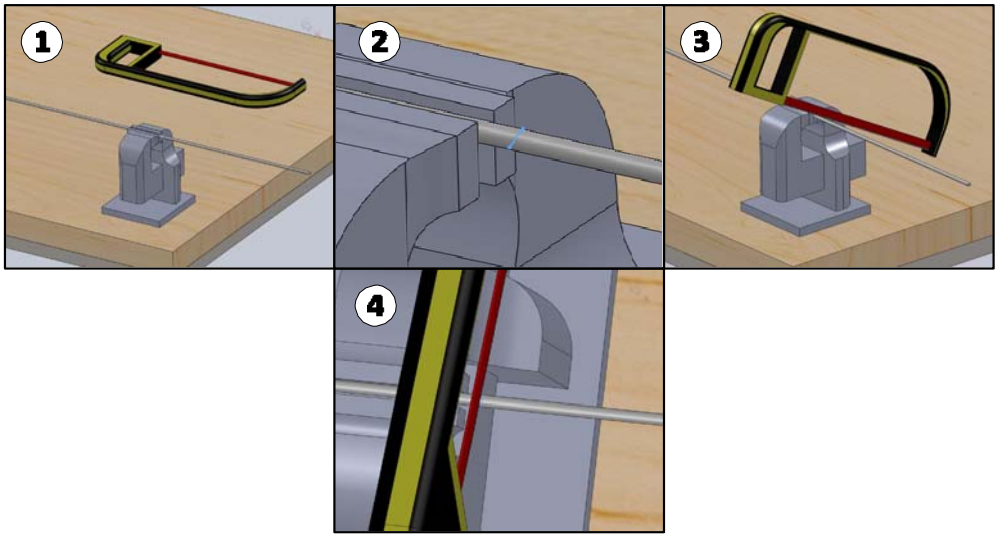


Figure 1: Clamping and cutting the rod- (1) Clamp the rod into the table vice. (2) Be sure to position the mark the correct distance away from the table vice. (3-4) Align the blade with the mark and start to saw.

Step 2: Grind all burs off the ends of the 12 13/16" rod caused by the **Hacksaw** with the **Bench Grinder**.

A. Make sure all objects are away from both grinding wheels of the **Table Grinder**. Wearing **Safety Glasses**, turn on the grinder.

B. When grinding any part, always look through the shield attached to the grinder, even though safety glasses are worn. Place steel rod onto grinder table as shown in Figure 2.

C. With a firm grip on the steel rod push it slowly into the wheel, rotating it with your fingers until all burs are removed. Do not remove too much material, only the burs are to be removed.

D. Remove the steel rod from the grinding wheel and shut off grinder.

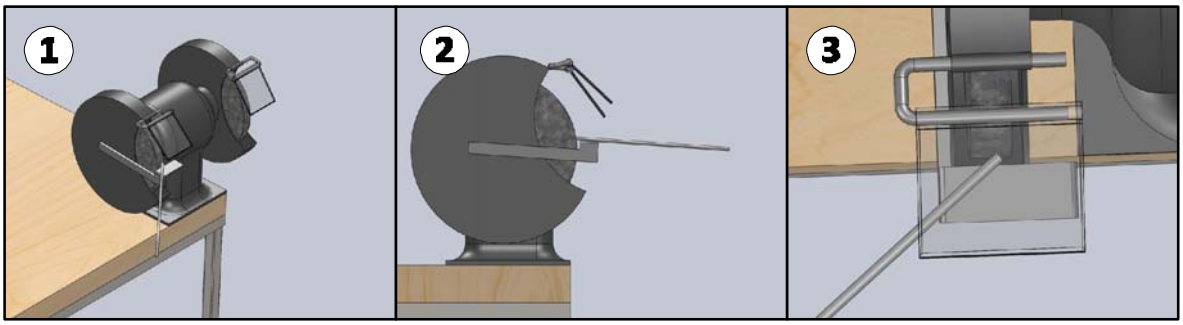


Figure 2: Removing burs with table grinder- (1) Place the rod on table of grinder. (2) Make sure the rod is flush with the table of the grinder. (3) Always look through the shield when using a table grinder.

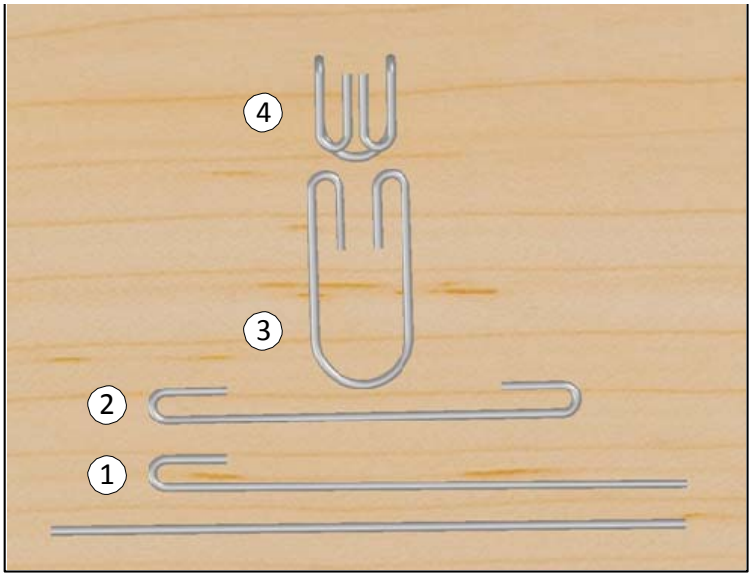


Figure 3: Sequence of bends

Step 3: Make **Bend #1** shown in Figure 3 using a **Table Vice**, **Self Locing Pliers, 3/8" Diameter Die**.

A. Clamp the **3/8" Diameter Die** into the **Table Vice** as shown in Figure 4.
B. Align one end of the cut rod with the bottom of the die.

Note: The die is cut to the proper length that allows you to use it as a measuring tool to determine where to place each bend in the correct location along the rod.

C. Make sure the rod is straight up and down. Then clamp it onto the die using a **Self Locing Pliers** as shown in Figure 5(1).
D. With your hands, gently start bending the rod over the die. Place your hands as close as you can to the die so that it bends only around the die.
E. After the rod is bent so far that it runs into the **Self Locing Pliers** as shown in Figure 5(2), remove the pliers. Use your hand to hold the rod in the correct spot on the die while you finish bending it all the way down to complete the 180º bend as shown in Figure 5(3).

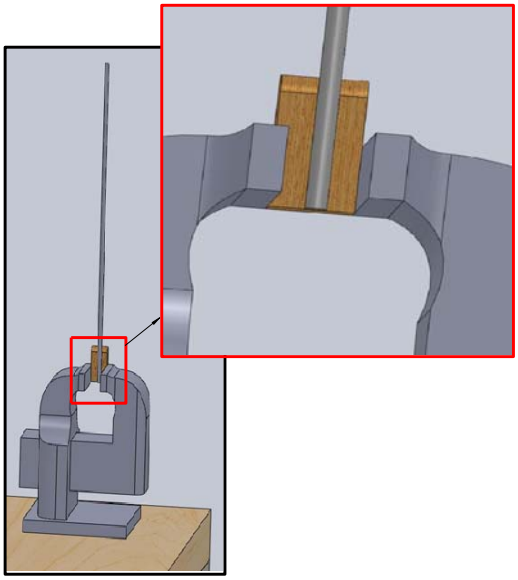


Figure 4: Clamping the die into the vice

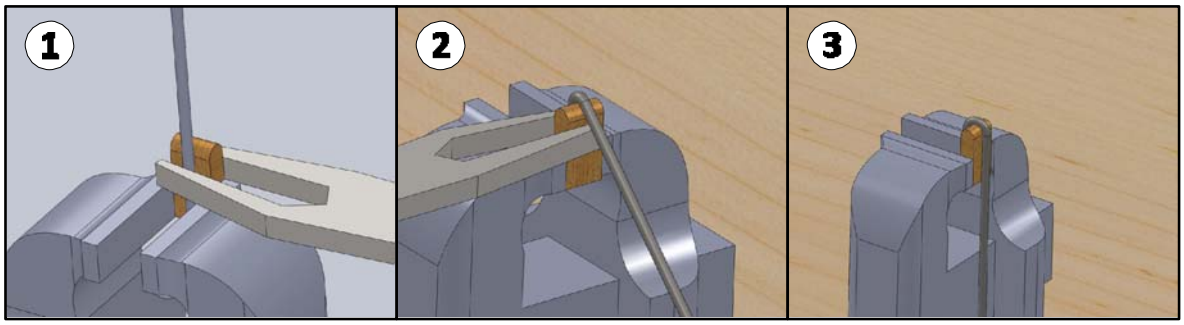


Figure 5: Bend #1- (1) Lock the rod to the die with a self locking pliers. (2) Carefully bend the rod over the die as far as possible. (3) Remove the self locking pliers and finish the bend.

Step 4: Make **Bend #2** shown in Figure 3 using a **Table Vice**, **Self Locing Pliers, 3/8" Diameter Die**.

A. Follow the procedure in Step 3 to make **Bend #2**

B. Make sure **Bend #1** is in the correct orientation with respect to the die as shown in Figure 6.

Note: If **Bend #1** is rotated slightly on the die while bending **Bend #2**, the bends will not be in the same plane.

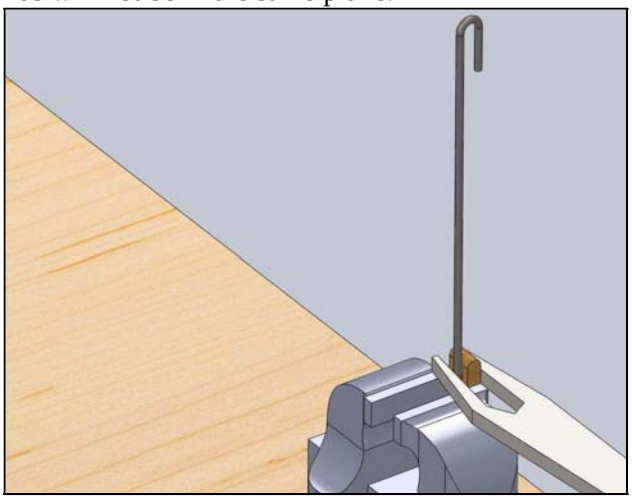


Figure 6: Bend #2- Position the rod so that that Bend #1 and Bend #2 will be in the same plane.

Step 5: Make **Bend #3** shown in Figure 3 using a **Table Vice**, **Bar Clamp , 1 1/4" Diameter Die**.

A. Clamp the **1 1/14" Diameter Die** into the **Table Vice** as shown in Figure 7(1). Be sure to clamp the die in the correct orientation. The side of the die missing the corner should not be the side that the rod is clamped onto as shown in Figure 7(2).

B. Align one end of the rod with the bottom of the die as shown in Figure 7(2).

Note: This will be done after the die is clamped snuggly, the picture is just a visual representation of where the rod is aligned with respect to the die.

C. Clamp the rod onto the die using a **Bar Clamp** as shown in Figure 7(4).

D. With your hands, gently start bending the rod over the die. Place your hands as close as you can to the die so that it bends only around the die.

E. After the rod is bent so far that it runs into the **Bar Clamp,** remove the **Bar Clamp**. Use your hand to hold the rod in the correct spot on the die while you finish bending it all the way down to complete the 180º bend.

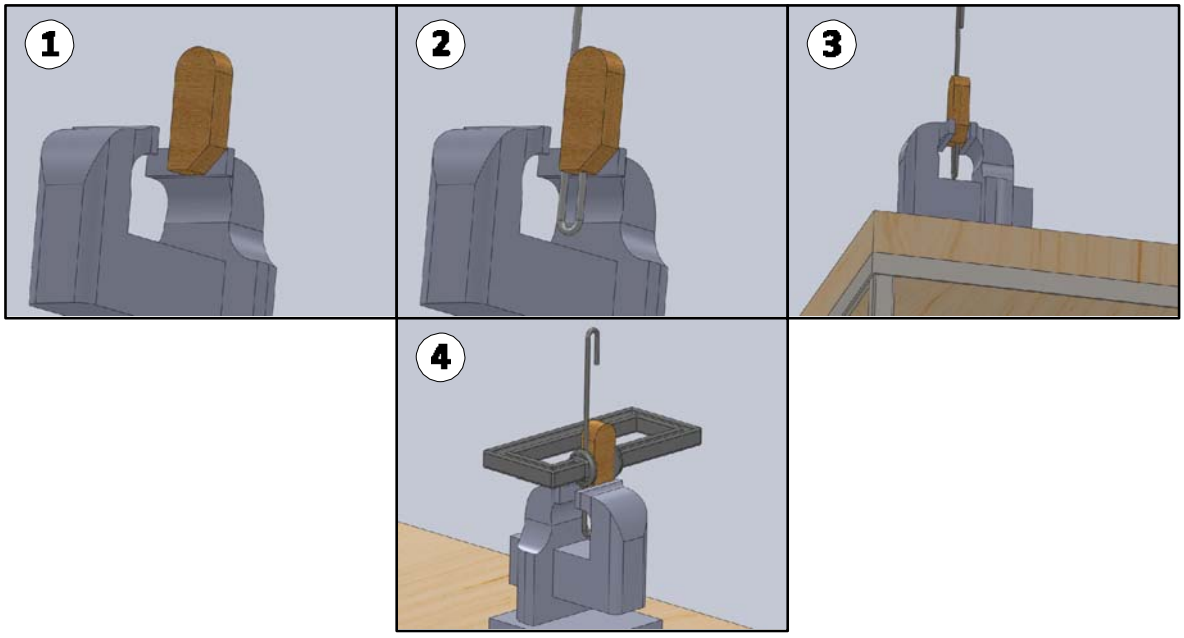


Figure 7: Bend #3- (1) Position the die in the correct orientation. (2-3) Align the rod so that the bottom of rod hits the bottom of the die. (4) Clamp the rod in place with a bar clamp.

Step 6: Make the final **Bend #4** shown in Figure 3 using a **Table Vice**, and two **3/8" Diameter Dies**.

A. Clamp the two **3/8" Diameter Dies** and the rod into the **Table Vice** as shown in Figure 8. Be sure to clamp the rod at the correct position with respect to the dies. The start of each radii on **Bends #1** and **#2** are aligned at the bottom of the two dies as shown in Figure 8(1). Make sure the two dies are straight up and down as well as the rod. Have one or more person hold the rod and dies while another tightens the vice. Once the vice holds the rod and dies in place make final placement adjustments before tightening the vice snug.

Note: The higher in the vice you clamp the dies, the farther you can bend the rod before it hits the vice. Make sure there is at least 1/2" of die clamped into the vice, any less then this, the dies might slip out of the **Bench Vice**.

B. With your hands, gently start bending the rod over the die. Place your hands as close as you can to the die so that it bends only around the die.

C. After the rod is bent so far that it runs into the **Bench Vice**, remove the rod from the vice and bend it the rest of the way by hand still using the die. Use your hand to hold the rod in the correct spot on the die while you finish bending it all the way down to complete the 180º bend. This may take more than one person to accomplish.

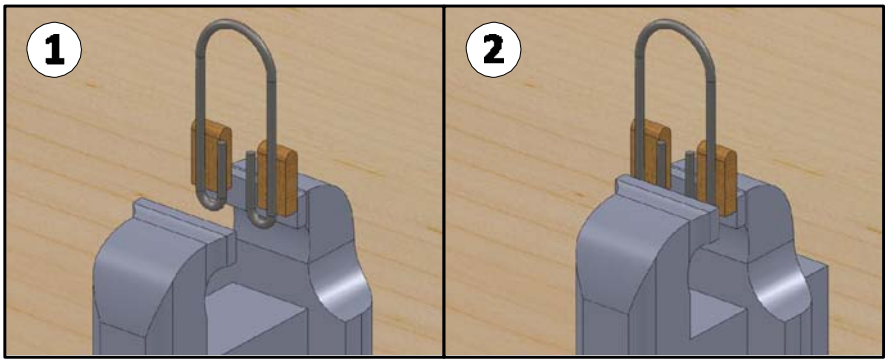


Figure 8: Bend #4- (1) Position the die and rod in the vice, so that the start of the radii are aligned with the bottom of the die. (2) Clamp the rod and die in place lightly, make final adjustments to set up, and then tighten vice snug.

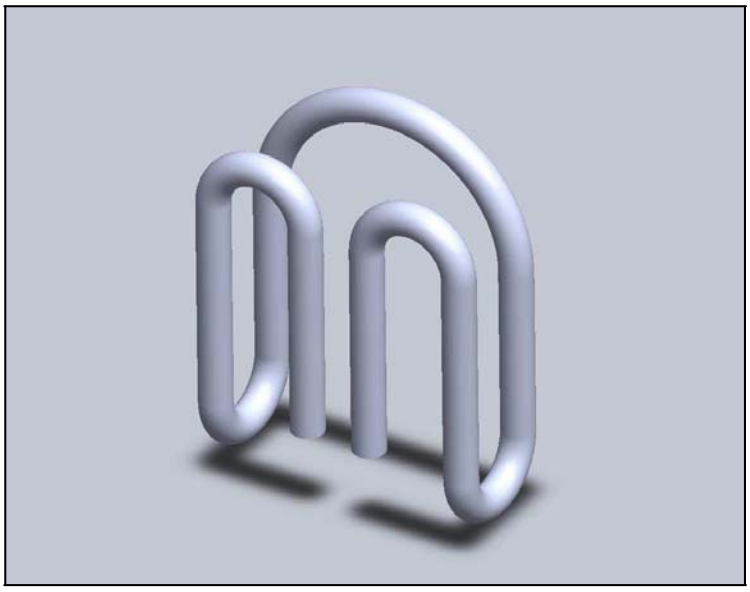


Figure 9: Final piece

Step 7: Assemble the two identical pieces together.

A. Position the two pieces as shown in Figure 10(1),

B. Move pieces towards eachother as shown in a side view in Figure 10(2), and in an end view in Figure 10(3).

C. Keep moving them together and and rotating them around until they are completely mixed up. If all bends are made corretly, the only way to get them apart without force is the way they went together. Putting them together is the easy part, getting them separated is the challenging part.

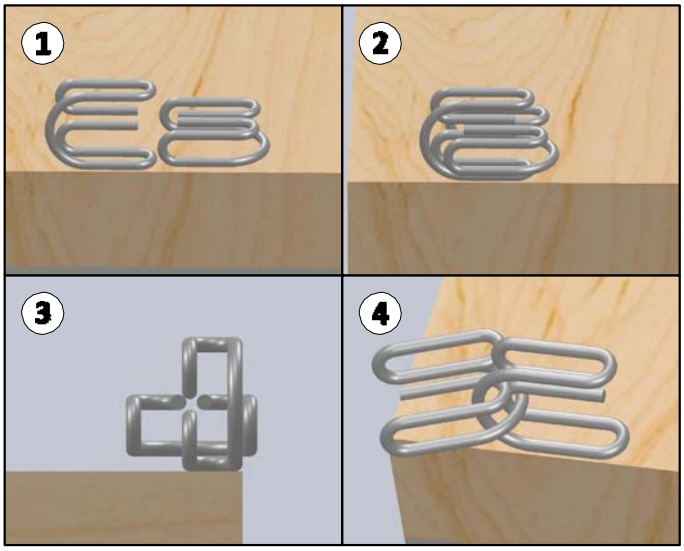


Figure 10: Assembly of puzzle pieces- (1) Position the two pieces as shown. (2-3) move the two pieces together to so the two straight portions of the pieces slide past each other. (4) Move the pieces around so they are not perfectly aligned any longer.

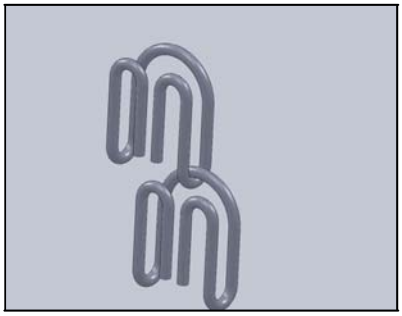


Figure 11: Final Assembly