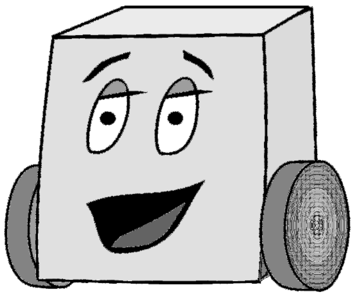


E11: Autonomous Vehicles

Fall 2011

Harris & Harris

Lab 3: Machining

Introduction

In this lab, you'll use Harvey Mudd's machine shops to make the sensor tower and sensor bracket. You will make these parts from technical drawings using a mill, drill press, and sheet metal tools.

Plan to divide into two groups. One will start with the sensor tower in the metal shop. The second will start with the sensor bracket in the sheet metal shop. Review the drawings for each component before you begin.

Sensor Tower

The sensor tower is built using the metal rod in your lab kit. You can assume the cross section of the rod is 0.5"X0.5"; you do not need to face these edges. However, the length of your piece is nonstandard and you will need to face both ends to length.

Some tips:

- Never place an endmill in a drill chuck!
- The path of the endmill relative to your piece should be counterclockwise. The opposite direction is called **climb milling** and it's bad for the bit.
- Follow mill speed suggestions posted on the shop walls
- It's easier to take off a little more than to put some back.
- It's a good idea to give your drill bit/endmill a hard tug and spin the mill by hand when you finish placing it in the mill. It's better to find out about loose/eccentric pieces when the mill isn't running.
- Always stop the machine before making measurements with calipers

Place your piece lying in the vice with an end sticking about a half inch out of the right side. You'll want to use **spacers**, to support your piece from below in the vice and to keep it level. With the proctor, use a **1" endmill** to face an end. Face refers to the process of taking off a small amount of material in order to ensure an even and smooth end. Start with the rod behind the endmill and gradually move it forward to make the cut.

Take the piece out of the vice and rotate it so that the other rough end is sticking out of the side. Keep 0.60" of the rod in the vice and let the rest hang out. Now you have to cut your piece so that it is the right length (1.000", according to the drawing). Cut it using the same process as before- you should take off 0.02" at a time, or possibly up to 0.1" if you go slowly. After a few passes, turn on the digital readout and press **reset** above the **x** button. Measure how big your piece is without removing it from the vice. How much more do you need to take off? You can easily reach this amount by watching the digital readout on each pass. When it reads your magic number, you're done. Verify your final size with calipers. Are you within tolerance? If you cut too much, you may have to start over. Be sure to not remove your piece from the vice and maintain the x-position of the endmill for the next step.

To cut your groove, you will use a coordinate system to cut the groove at the top of the sensor tower. The first thing you must do is define an origin. We can take advantage of the endmill's current position to do this. The endmill is currently positioned to barely scrape the end of your piece. This x-location is your zero point in x. Press the reset button for the x-coordinate in the digital readout to save this place. You can easily find a zero point in z by moving the endmill to so that it is above the top of your piece. Turn on the mill and raise the platform until the endmill barely scrapes the top surface. This is your zero in z. You need to keep track of this point manually using the markings on the z-axis crank. Every line on this crank's measurement system is 0.001". Now, locate the line on the drawing that is the maximum penetration and decide what its x and z coordinates are. You want to remove material so that setting x and z to these coordinates and manipulating y, you will not remove any additional material. Now, set z to the final desired position, while manipulating the other coordinates to keep the mill from contacting your piece while it is not running. Now, in the same process as reducing the length of your piece, you can take off material in passes until x is in its final desired position. Once the mill is at the correct x and z coordinates, this cut is complete.

To drill the 0.2" phototransistor hole, you will also use a coordinate system. This time, however, you must define your coordinates using an edge finder. The edge finder works by spinning with an eccentricity that is corrected when it contacts a flat surface (aka the edge of your piece). Place the edge finder in a drill chuck and tighten it with a chuck key, and place the chuck in the mill. Turn on the mill and adjust your coordinates until the edge finder is barely touching the side of your piece. The digital readout now corresponds to a point 0.1" away from the edge of your piece because the edgefinder has a diameter of 0.2". We can compensate for this by hitting (desired coordinate)-1-0-0-abs on the digital readout. Hitting the minus-button may be required depending on what side you are of your piece. Check to make sure your set coordinate makes sense with respect to your piece. Once you have a coordinate system, you can precisely locate where to put your hole using the digital readout. Select the proper sized drill bit and place it in the drill chuck. Drill through the piece, backing out to remove material frequently. Ease up on your downward pressure when you're about to break through. This will reduce any burrs that may occur.

Similarly, drill a hole on the bottom for a machine screw. Mount the sensor tower in the vice, taking care to keep it vertical. Use the edge finder to set the coordinate system. Place a bit with the desired inner diameter in the chuck. When drilling, use the markings on the drill plunger to gauge your depth.

When tapping, make sure you use the correct size AND thread density. If you don't match both, your tower will not fit on your robot. Turn the tap until it seems solidly in place. From here on out, get in the pattern of going ½ turn forward, followed by ¼ turn back. Lubricate your hole with tapping fluid before beginning. Keep track of your depth so that you don't go too deep or too shallow. If the tap gets unreasonably difficult to turn, STOP! Over turning is how you break taps. Back the tap out and look for debris in the hole or other obstructions. You may have to re-

Femove any burrs with the files located in the back corner of the shop.

Clean up your workspace. Vacuum around the mill and return the tools you have been using.

Sensor Bracket

The sensor bracket requires use of the sheet metal shop. You will receive a piece of sheet metal that is 1.3 by 1.75 by .0625 inches. The bracket requires the use of calipers, the corner cutter, a drill press, and a sheet metal bender. The calipers will be used to measure and mark the part for production. The corner cutter will chop the sheet metal down to 1.1 x 1.75”. The drill press will be used for the holes. The sheet metal bender will be used to bend the plate to form the proper shape.

The first thing to do is understand the machine drawing for the part. The drawing has dimensions to show the size of the plate, where the holes are placed, how big the holes are, and a dotted line to show where the part should be bent.

After you understand the drawing, you should use a pair of calipers to mark the part. This can be done by expanding the calipers to the correct dimension and moving one edge of the calipers across the surface of the part while the opposing jaw is used to align the calipers against the edge of the part. This way lines are etched parallel to the edges. The lines etched into the aluminum sheet metal should intersect where the holes are centered. One line should be made to indicate where the plate is to be bent with the sheet metal brake. Another should be made to indicate the excess metal to chop the part down to size. Make several lines such that there is an intersection of lines wherever a hole is to be drilled. If you desire, you may use a center punch to make a small divot at each intersection. Place the tip of the center punch over the intersection and tap lightly with a mallet or hammer. This will make it much easier to drill in the correct place.

Use the corner cutter to chop the plate down to width. If the jig is properly positioned, the cut will be square and of the right size. Note: it will take some effort to hold the metal piece in place while you perform the cut. Hold the piece tightly with one hand and take advantage of the long lever arm of the tool with your other arm to execute the cut.

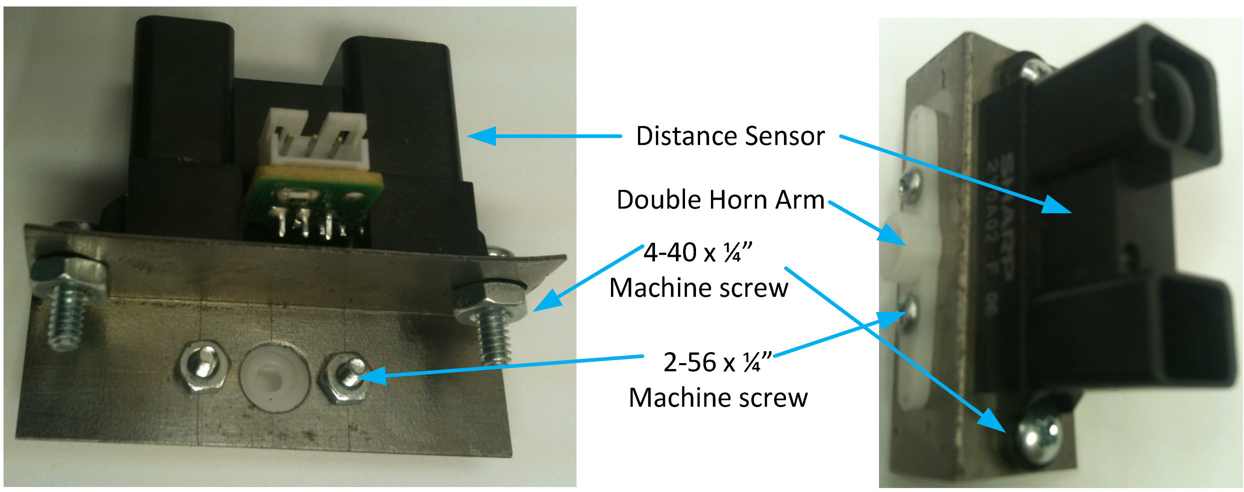
The drill press, located in the wood shop, should be used for the five holes. Ask a shop proctor for the drill bit required to make the holes. The plate should be clamped in the drill press vice. Make sure to put a piece of wood under the plate of aluminum. This is a sacrificial piece that will prevent the vice from being drilled. The vice should be aligned such that the drill bit is centered on the spot where the hole should be located. The hole can then be drilled by turning the drill press on and pushing the drill bit through the part using the lever on the side of the drill press. This process is repeated for the other hole. Once the holes are finished unclamp the part from the vice and go onto the next operation.

Once all of the holes are finished the bracket is ready to be bent. The part should be placed flat on the sheet metal bender’s surface underneath the angled jaws. A small lever on the side is used to lower the jaw so it holds the part flat. Locate the bending line so it is collinear with the jaws edge. Hold down firmly with the jaw lowering lever, and bend the brake's table up with the other lever. This will bend the part at the tip of the jaw. Move the lever up until the plate is bent at 90 degrees. Lower the table and open the jaws. The bracket is now finished!

You will also need to use the drill press to widen two holes in the servo double horn arm to mate with the bracket. Find the double horn arm in your servo bag. Identify the two small mounting holes aligned with the 0.090" holes in the bracket. Drill these holes wider to 0.090" as well.

Mounting the Distance Sensor

Verify the positions of the holes in your bracket by connecting it to the distance sensor as shown below.



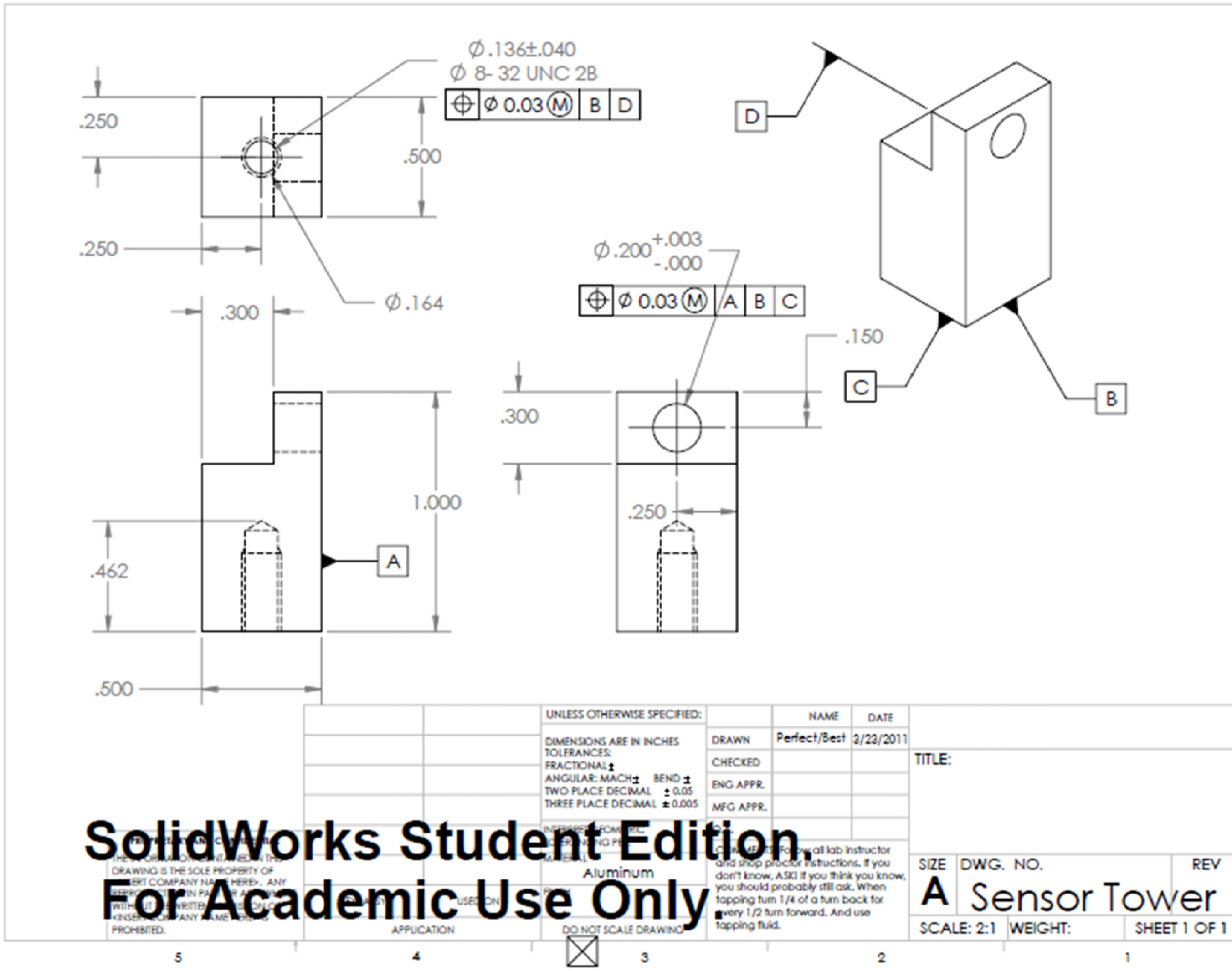
Use a pair of 2-56 x ¼" machine screws and nuts to attach the double horn arm to your bracket with the arm underneath the bracket and the nuts on top of the bracket.

Use a pair of 4-40 x ¼" machine screws and nuts to attach the distance sensor to the bracket.

If you have difficulties, your holes are located outside of their tolerances. Redrill the hole as necessary for the components to fit.

Checkoff

Your parts should now be complete. See your lab instructor to check off your parts for being in spec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UNLESS OTHERWISE SPECIFIED:
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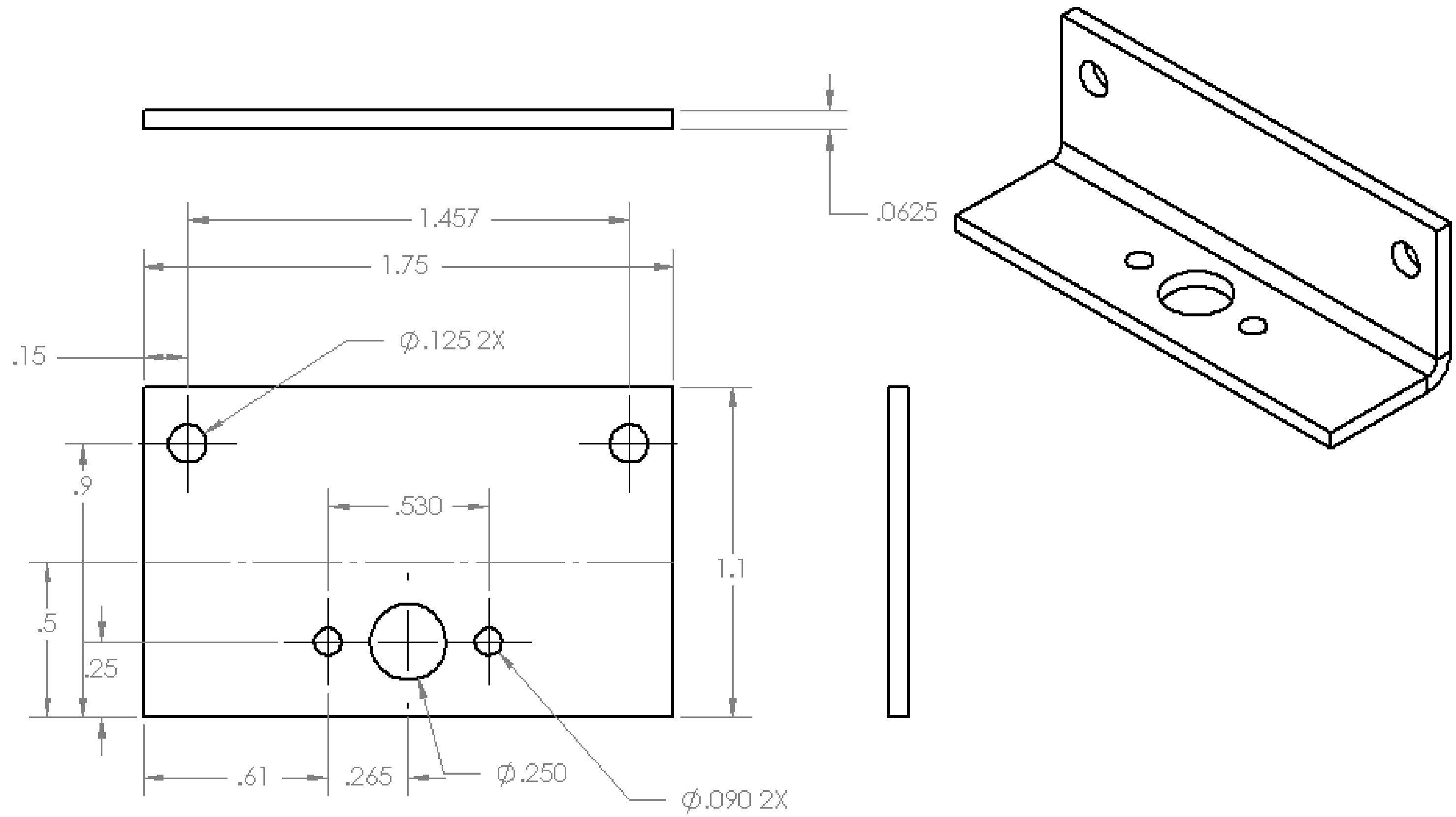

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PROPRIETARY AND CONFIDENTIAL

TITLE:

SIZE	DWG. NO.	REV
A	Sensor Bracket	

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