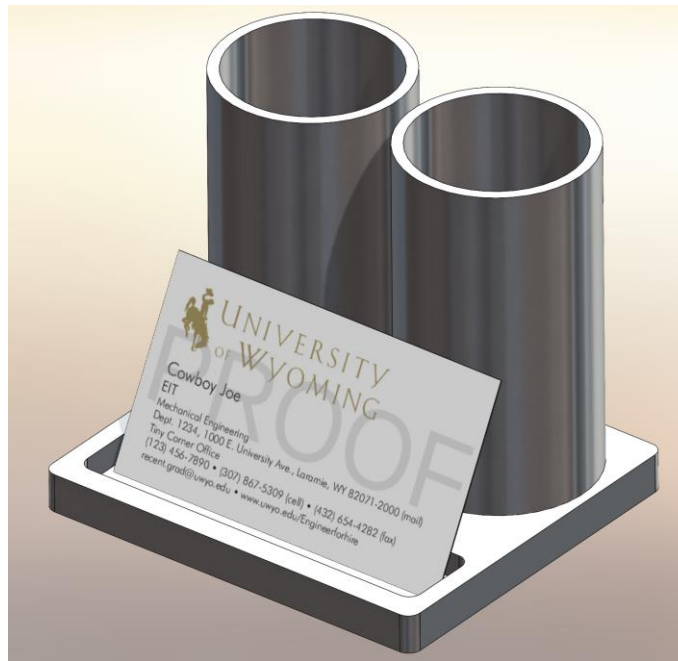
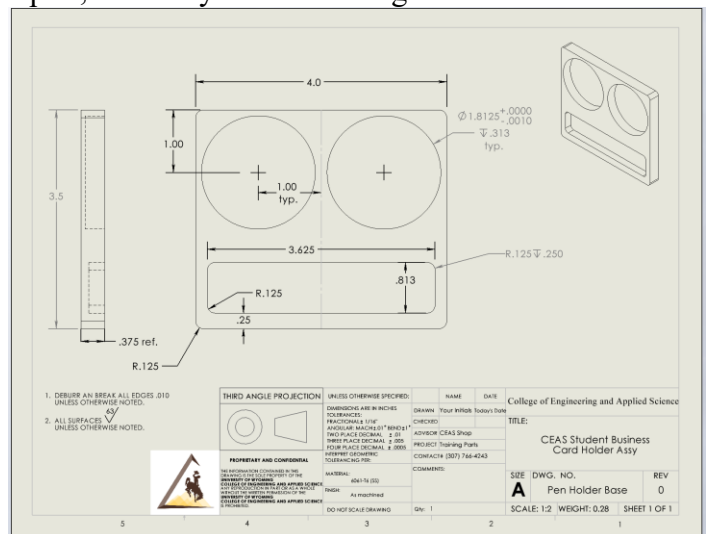
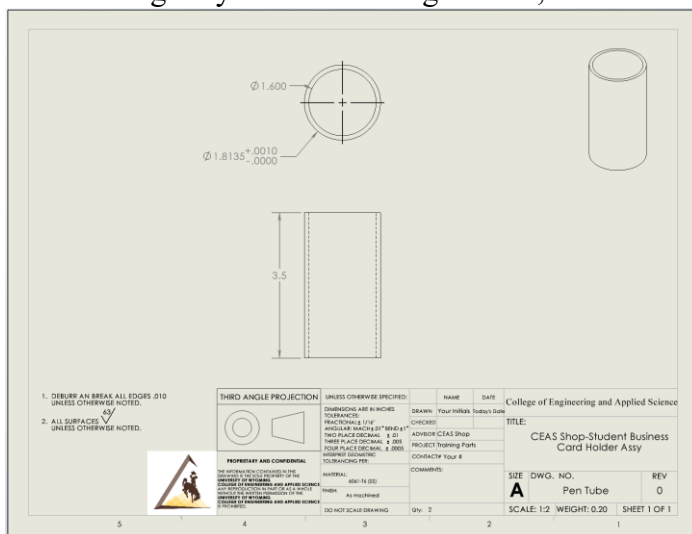
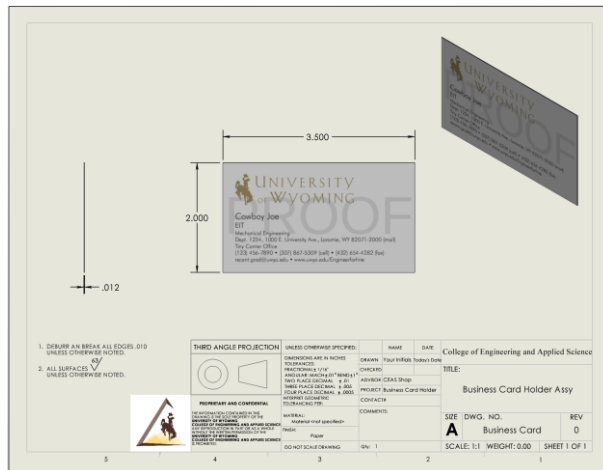


**Outline for the design, manufacture and assembly of a custom business card & pen holder**



1. If you haven't already, navigate to the UW CEAS Shop's website (<http://www.uwyo.edu/ceas/shop/>) where you'll find a button taking you to the Student Handbook.
  - a. Read the handbook and click the link at the bottom to take the Shop Safety Assessment. Upon successful completion of this assessment (80% passing grade), proceed to step 2 below and begin building this project.
  
2. Using only the 2D drawings below, re-create these part, assembly & 2D drawing files in Solidworks:





3. After you've completed steps 1 & 2, setup a time with the Shop Manager ([uw-shop@uwyo.edu](mailto:uw-shop@uwyo.edu) or come by the shop) to review your SW model & 2D drawings, then discuss the next steps for the training and machining process.

### **Machining Process for 6061 Aluminum Business Card & Pen Holder**

1. Using the **OMAX 2652 Waterjet**, cut the Pen Holder Base rough outline shape, creating a DXF file from your Solidworks model
  - a. Create the 3D part, then right click the surface to be water-jet cut using the “Export a DXF File” tool. Beware not to click a face with a chamfer or radius which won't cut to the correct size.
  - b. Material to be pulled from the CEAS Shop's Inventory racks. Please use scrap/small pieces first, then larger sheets, only if necessary.
2. Using a **Vertical Milling Machine**, “deck” cut the top and bottom surfaces of the base plate
  - a. This operation provides a flat, even surface to clamp in the vice, otherwise you will be working from a non-parallel surface and will end up with leaning tubes.
3. Using a **Vertical Milling Machine**, machine the business card recess pocket and counterbores into the base plate
  - a. Will need to use correct size tooling to achieve proper corner radii and boring head on the mill for the non-standard size counterbores
    - i. Using a 1.75” 2-flute HSS endmill (or other suitable roughing tool), rough cut counterbores for tubes, followed by final boring using boring head tool to bring ID to 1.813” for press-fit operation
  - b. Business card pocket machining options 1 & 2 (plus others you may think of):
    - i. Using a 3/4” end-mill, rough cut one width pass the full length of the slot, in correct location, followed by using a 1/4” end mill to trace the full pocket path, creating proper corner radius' and cleaning up edges
    - ii. Using a smaller end-mill (say 1/2”), rough out the entire pocket area, then change tools and use a 1/4” end mill to follow the same outline shape, removing material mainly from the corners and cleaning up the long edges
  - c. *Once base plate is machined, deburr or break all edges to eliminate any sharp burrs.*



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4. Using the **Carbide Chop Saw** or **Horizontal Bandsaw**, (with training/assistance from a Master Technician or Shop Manager), cut off (2) 6” lengths of 2”x1/4” wall 6061-T6 Aluminum round tubing. These will be long enough for making 2 individual tubes and have clamping area in lathe chuck.
5. Using the **Manual Metal Cutting Lathe**, chuck up one of the tubes so that 4” sticks out from the face of the lathe chuck. Face cut this end until it is straight and true.
  - a. Second, with the work still secured tightly in the chuck jaws, drill out the ID as close to size as possible (1-9/16”), leaving some room for final ID boring.
    - i. After rough drilling is complete, using a set of calipers (or inside micrometer for more accurate results, but not necessary on this feature), measure the ID of the tube. Calculate the “difference” between your drilled hole and the final bore diameter called out on your print.
    - ii. Once you’ve calculated this difference, switch to an ID boring bar to complete final ID boring. Be sure to set machine to a slow enough speed to avoid excessive tool chatter and poor surface finish. You’ll want to make these ID boring cuts in a few “passes”, starting with heaviest cuts (0.025”-0.030”), then ending up with a smaller “final pass” cut of 0.005-0.010” (diameter).
    - iii. After the ID of the tube is brought to the correct size, move on to the OD turning operation.
  - b. Third, you’ll need to turn the OD precisely to the correct press-fit dimension.

**BEWARE:** Outer diameter size and surface finish of the tube at this point will dictate the success of the press fit. So **DON’T TAKE OFF TOO MUCH MATERIAL AND MEASURE OFTEN WITH AN OUTSIDE MICROMETER.** See Master Technician’s or Shop Manager for proper instruction on using an **O.D. micrometer.**

- i. When turning material off an outside diameter, you’ll complete this in several passes. You’ll want to make a first “skim cut” of the entire length to ensure the OD is round, since many types of tubing aren’t perfectly round and thus won’t press-fit as-manufactured. Once you’ve completed a skim-cut on the entire length to be pressed in (ensuring you’ve made contact everywhere and there are no bare spots that haven’t been cut), measure the OD of the part with an Outside Micrometer. This OD will be your starting point for the OD turning operation. Like in the previous ID boring steps, you’ll need to calculate the difference between where the part should end up and what it measures right now.
- ii. With your difference calculated, begin to turn material off the OD in passes of 0.040”-0.050” from the diameter, until the OD gets within 0.025” from final.
- iii. At this point, you may want to re-evaluate your speeds and feeds to produce a higher quality surface finish until you reach your final OD for the press-fit. Keep in mind you should end up with 0.001-0.0015” interference for a snug press-fit that won’t spin or come apart.

**BEWARE: PRECISE MEASURING AND SMALL, CONTROLLED CUTS AT THIS POINT WILL HELP AVOID OVER-CUTTING AND MISSING THE PRESS-FIT. ALSO BEWARE THAT IF YOUR MATERIAL IS ABOVE ROOM TEMPERATURE, COOL IT OFF WITH COMPRESSED AIR TO REACH ROOM TEMPERATURE FOR AN ACCURATE O.D. MEASUREMENT.**



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- c. Once you've turned a sufficient length of the OD to the proper size, you'll need to use the "parting tool" to cut the part to a rough length, 1/8" longer than the final print overall length dimension, followed by facing the "parted" end like you did first in step 5.
  - i. Remove old stock tubing from lathe chuck jaws and place in Aluminum recycling bins.
  - ii. Place your final machined tube back into the lathe jaws with the parted-end sticking out. Proceed to face that end off until straight and true, like was completed in step 5. Disable the machine power and measure overall length, then continue to face off until the part length is reduced to the final print dimensions. The parting cut can typically be a rough surface finish, so the final facing operation should clean it up.
- d. Once you've completed Facing, Drilling, ID turning, OD turning & Parting of the 1<sup>st</sup> tube, measure your final OD and length, then evaluate the results. If you cut it too small, keep that in mind as you prepare the 2<sup>nd</sup> tube and try not to make that mistake again. Proceed to machine the 2<sup>nd</sup> tube, repeating steps a-c.
- e. *Once both tubes are machined, deburr or break all edges to eliminate any sharp burrs.*
- f. After you've machined both pen holder tubes, contact the Shop Manager or a Master Technician in order to train and help you operate the hydraulic stand press to fit the tubes into the base plate. If the tubes ended up being undersized, we will consult about your options to remedy that as well.
- g. Using the **Hydraulic Stand Press** and appropriate blocking-Align and stand the tubes up over the bores they'll be pressed into. Ensure the bleed valve is closed and pump the jack arm to start moving the ram down on to the top of the tubes. This press-fit of 2 fairly soft Aluminum parts shouldn't take a lot of force, so a few strokes of the jack arm should press the components completely together without a lot of resistance. If the press seems really difficult, something is probably wrong. The interference fit may be too large or the pressed parts are severely misaligned.

*For those who are interested, we have various tools that can be used to engrave your name into the bottom of the base plate after completion (i.e. deburring pen, engraving tool, stamps, Intelli-ETCH on Waterjet)*

6. **Review** your experience, lessons learned and how these concepts apply to Engineering designs with either the Shop Manager or Master Technicians. As you complete each step of training on different equipment, contact the Shop Manager to receive a punch on your CEAS Shop Training Card for that task. By the time you complete these parts, you should have received all of the punches that accompany reading the handbook and taking the quiz, as well as training on the OMAX 2652 Waterjet, Carbide Chop Saw or Horizontal Bandsaw, Manual Knee Mill, Manual Lathe, Deburring/Grinding Wheels and the Hydraulic/Arbor Presses.



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**Conclusions**

This project is intended to give students a taste of machining some simple parts, using various equipment, techniques/tools and what their designs take to build once they’ve Engineered and designed them in a CAD based software package. The students will leave with a practical item to be used in their professional careers showcasing their knowledge as well as some very rough hands-on skills operating manual machines.

However, this is only the tip of the iceberg when it comes to all the available and standard industry practices of manufacturing, let alone all the capabilities of CNC machining, of which none were mentioned here. **We estimate this project will take 15 hrs of shop time for students to complete and we will charge a \$100 all-inclusive fee per student**, slightly less than 1 credit hour cost for AY 21. This fee will cover the cost of the materials plus a small fee for our staff time spent training and assisting students in their manufacturing efforts. Scheduling of these projects is to be a collaborative effort between the interested students and the CEAS Shop staff, according to their current workloads and to be completed during normal CEAS shop business hours, M-F, 7a-3:30pm, or otherwise posted outside the shop’s main office doors.

**Estimated Manufacturing Time for Student Project-Business Card & Pen Holder**

<u>Manufacturing Step</u>	<u>Estimated Student Labor (hrs)</u>
Reviewing 2D PDF drawings	1
Creating SW 3D model-Parts, Assembly & 2D drawings, GD&T	3
Export DXF file & waterjet cut base plate outer shape	0.5
Machining base plate-Decking & recessed pockets (rectangular & rounds)	4
Deburr/polish base plate	0.25
Cut (2) 2” x 1/4” wall Aluminum tubes, 5”L for lathe operations (~10” OAL)	0.5
Drill/Bore ID of Aluminum Tubes	1.5
Turn OD of Aluminum Tubes	2.5
Part-off Aluminum tubes and face end	0.5
Deburr/polish Alum. Tubes	0.25
Press fit tubes into base plate	0.5
Final inspection, review and testing	0.5
<b>Totals</b>	<b>15</b>