BEGINNING SCULPTURE

Fall 2021
Tasha Lewis

Tuesday & Thursday 2:10pm to 4:55pm
Room 129 • Metal Shop • Wax Room • Plaster room • Sculpture Yard

alewis80@vols.utk.edu
Office Hours: Tuesday and Thursday 5 - 5:30pm and by appointment.

Project 1: Metamorphosis in Cast Aluminum

Sketches due: _____

Critique: September 21st, 2021

Project 2: Site-specific Response in Steel

Sketches due: _____

Scale Maquette due:_____

Critique: October 26th, 2021

Project 3: Digital Self-Portrait

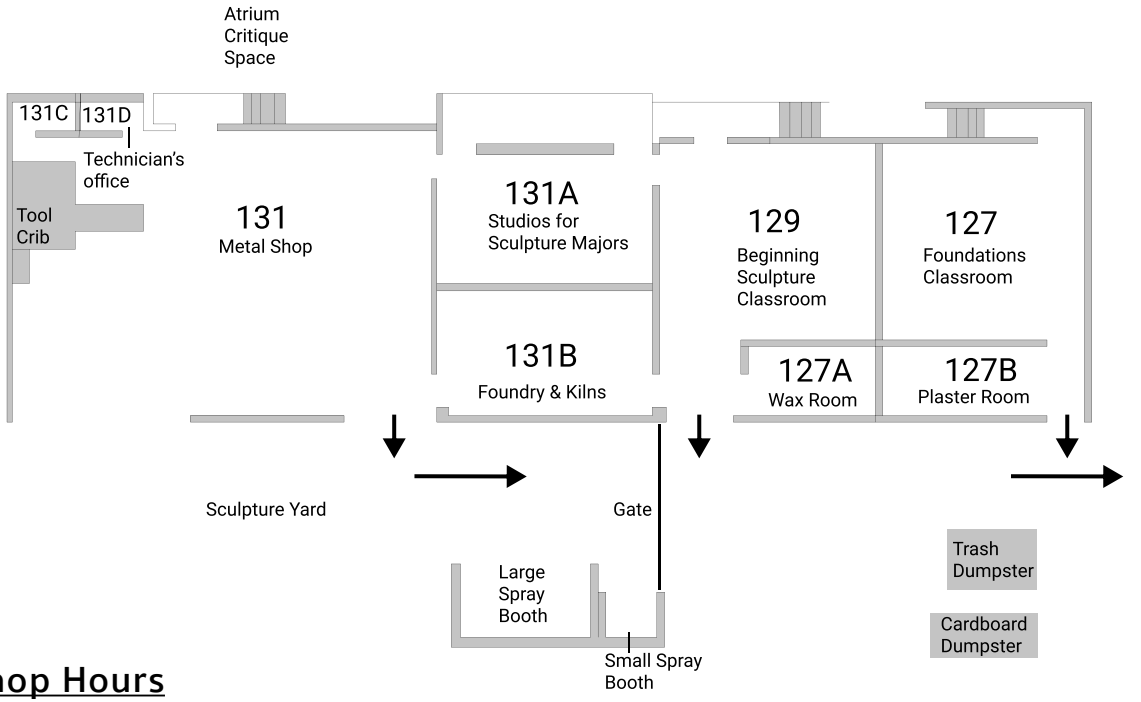
Sketches due: _____

Critique: November 30th, 2021

Sculpture Spaces

Welcome to the sculpture area!

In Beginning Sculpture we will be working across rooms 129, 127B, 127A, 131, and the sculpture yard. All of the rooms have doors which exit to the outside of the building in case of an emergency.



Shop Hours

The sculpture classroom (129) is open whenever the Art and Architecture building is open, so you will always have access to your cubby and works in progress.

The other sculpture spaces and tools are locked during off-hours, so you need to pay attention to when the shop hours are each semester. They are usually in the evenings a few days a week from 5-9pm. There will be up-to-date postings, and COVID protocols to follow for signing up for time in the shop in all of the sculpture rooms throughout the semester.

Casey Fletcher (cfletc11@utk.edu) is our 3D area technician and is very knowledgeable about the tools and processes we will cover in this class. He can help you get oriented on a new tool, or brainstorm ideas for issues you may encounter. Casey, the Shop Monitors and I are all here to help you make awesome work, so don't hesitate to ask questions.

Lost Wax Casting Overview

Our first project centers around the ancient art of lost wax casting. Practiced throughout the world and going back thousands of years, this process remains essentially unchanged to this day.

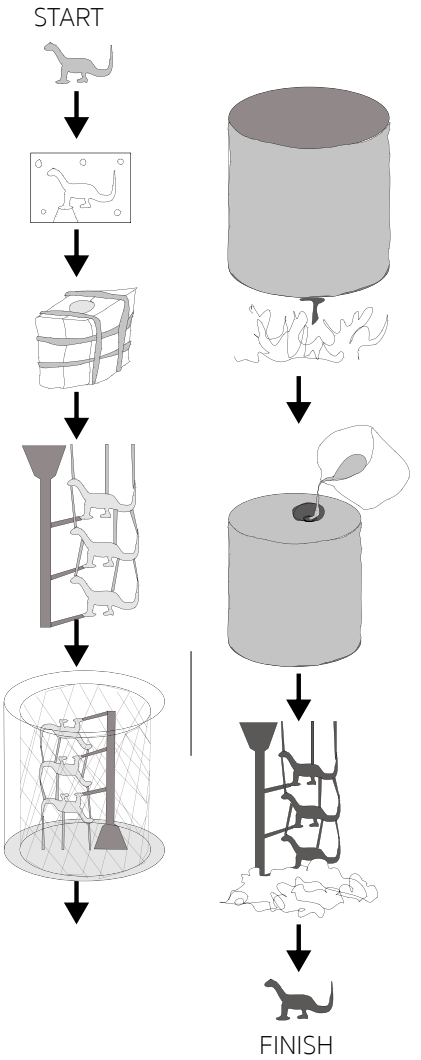
You will begin with a model, in this case a small toy or figurine. By breaking the model down into sections, you will design a plaster mold which will capture all the detail of the original model. When the mold is finished you will be able to re-assemble it with a space at the center where the model used to be. This hollow space can then be filled with melted wax which is liquid when hot and solidifies as it cools.

Once you have wax copies of your model you can manipulate them with tools, adding detail or re-imaging the form entirely. Your various wax copies will be assembled into a tree with rods and a cup so that we will be able to channel molten metal into them.

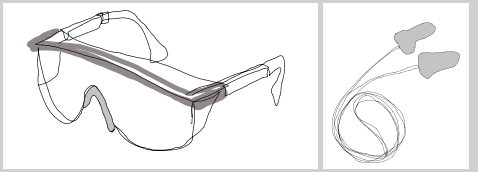
We will make a final mold, an investment mold, that is made with a form of plaster which can be heated to 1200˚ and entirely encapsulates your wax tree of casts.

Flipping this mold upside-down in the kiln will allow the melting wax to flow out once the temperature rises. When all the wax is gone we are left again with very detailed negative spaces, each one representing the desired forms.

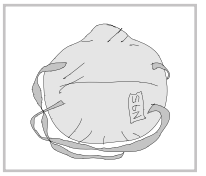
On the day of the pour, we will heat a crucible filled with aluminum ingots to melt in our furnace. With all the molds out on the line in the foundry, we can then fill each one with molten metal. The metal will fill up the spaces for both the pour cup, rods, vents and the shapes of the wax models. Once it is cooled we can break away the plaster mold and reveal the tree now totally made out of aluminum. The castings can be cut away from the rods and prepared for presentation.

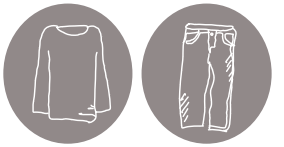


Personal Protective Equipment (PPE)



Safety glasses will be available in the classroom with cleaning products for you to sanitize them before and after use. You should wear them any time we are working with dust or manipulating material. We will have disposable earplugs for times when you need ear protection.

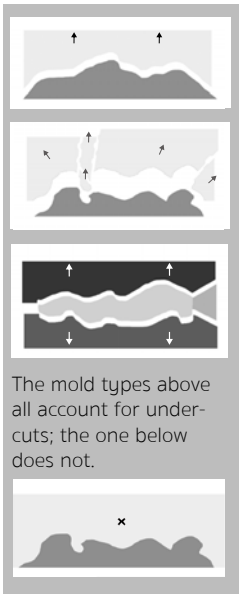




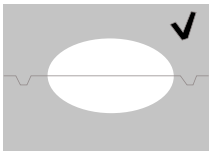
You are responsible for bringing an N95 mask for particulates along with a zip-lock bag to store it in between uses. You must wear this when working with dusts, particularly plaster and silica.

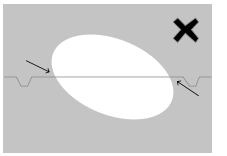
You should come to class with long pants and long-sleeved shirt which you do not mind getting dirty and you should always wear sturdy closed toed shoes while in the sculpture area.

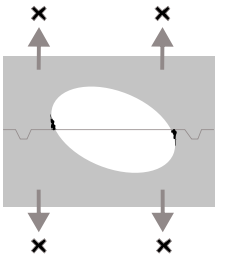
Mold Making Basics



The mold types above all account for undercuts; the one below does not.





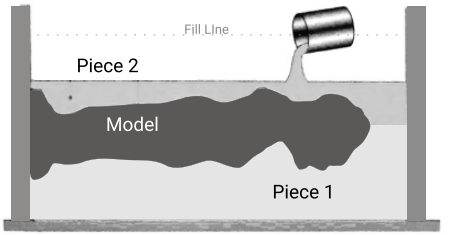


The most important thing to understand when designing your mold is how to choose a parting line/s without undercuts. A parting line is the division between mold sections. An undercut is a change in the surface direction which creates a pocket and would break the mold section.

We are using a rigid mold made with plaster, so the sections must remove from the model without having to change shape at all (things are slightly different if you are using a flexible mold material like rubber). In order for them to be removable, you cannot have any undercuts, or areas of the model which impede the model, or casting, from being taken out without breaking the mold.

In the examples to the right you can see that the same simple form can be made into a successful and unsuccessful mold. Always try to picture the action of removing the mold blocks in a single direction: if there is any part of the model that would stop that movement you will need to re-design it, or add another mold section.

Two-Part Plaster Mold

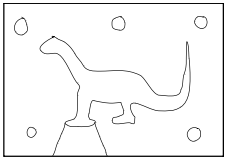


Because many toys are made with two-part molds, there may already be a visible parting line on the object when you start. If there is not, practice splitting the form into a top and bottom as in the image to the left.

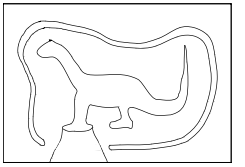
The first part of the mold is set up by filling the area around the model with water-based clay and leveling out the surface before carving out your keys and painting mold-release on the surface. You then pour plaster on top. Once it hardens, you flip it over and remove the clay. Then add more mold-release and pour the second side of the mold. After it is cured you can split them and remove your model.

Keys

The idea of a key is to create a variation in the surface around the outer edge of your model, at least an inch and a half away, which interlocks both pieces of the mold without creating undercuts. In the examples to the bottom- left, you can see that the best keys are wider than they are deep and have gradual angles or curves. A 90˚ corner may not be an undercut in actuality, but it will be stressful on the mold and would break more easily than a semi-circle.



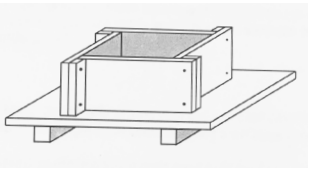
Remember you can key in individual dots or make a continuous channel depending on your style, the kind of mold, or the space you have. Keys should be at least 1.5 inches away from both the model and the edges of the mold.

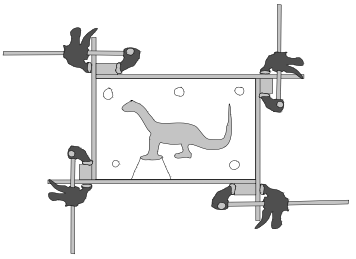


Setting-up in the Plaster Room

Before you begin, grab some craft paper from the roll and cut it to the size of your workspace, approximately 18in x 18in. Also make sure that your parting line is clearly drawn on the side of your model in Sharpie.

Next, set up four cottle-boards to make a rectangular volume around your model. You want to have about 2.5in of space around your entire model, as this will allow space for keys and ensure your mold is sturdy. You can either secure the cottle-boards with screws or clamps as seen in the diagrams to the right. The cottle-boards have one end with a thicker piece of wood which supports the connection point with the thin side of the next board. This thicker part faces away from your model. Using this method you can make rectangles and squares of every size, only limited by the length of the cottle-board. Once you have determined the size of your outer walls, trace the inner dimensions with pencil on your paper and remove the cottles.

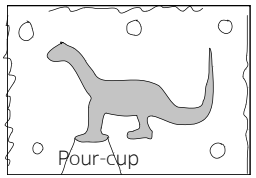




Adding Clay

Adding the foundation of water-based clay is one of the most important steps in mold-making. I advise you to move through this whole process in one sitting. Grab a few handfuls of clay and elevate your model off the table making sure that the parting line is parallel to the table surface. Continue adding clay and smoothing it down so that you are creating a plane that is bisecting your model along the parting line. Use clay tools to flatten and even out the surface. Pay special attention to the clay plane where it connects with the model.

After working to build it out on all sides, go back in with the detail tools to make sure the connection between the clay and the model's parting line is even and smooth. After that point, re-assemble the cottle-boards boards around the clay and finish filling in all the way to the edges. Remember to take your time with this. If you notice the clay drying up at all, spray it with a little water. If you must leave it for any amount of time, make sure it is fully covered in a plastic sheet to keep in the moisture.



Using small coils of clay seal up the inside seams of the cottles by pressing your finger along the corners and spreading the clay all the way to the top of the cottle-boards. Remember that very shortly you are going to be pouring liquid plaster into this container, and so you do not want it to leak. If the clay dries up it will shrink, and that will cause a lot of issues.

When you finish smoothing, build up your pour-cup, half of a cone that will be the opening for your mold, and carve out your keys. The pour-cup needs to be in direct contact with both the model and one side of the cottle-boards.

Painting on the Release Agent

We will be using Murphy's Oil Soap as a release agent. It acts as a barrier between things you do not want to stick together, like your model and the cottle-boards with the plaster mold.

In a small cup pour out a capful of the oil soap, you will not need much. Take a paint brush and wet it in the sink so that it drips a little. Adding the brush to the soap froth them together. If you don't see many bubbles, add a few more drops of water and keep whipping the brush into the soap. Once you have a foam you can brush it onto all the surfaces within your cottle-boards, including the clay and your model. Let it dry and then froth up the soap for a second coat. You are now ready to prepare the plaster.

Calculating the Volume of Plaster

Use the formulas to the right to calculate the desired volume in cubic inches using the inner dimensions of the cottle-boards for the length and width, and the distance between the parting-line plane and the top of your mold for the height. Remember the top of the mold needs to be about 2.5in above the highest point on your model. You should mark this level with tape on two sides of the cottle-boards.

For our purposes, the ratio of plaster to water is 100 parts of plaster by weight to 70 parts water by weight. According to this ratio, **there are 16.316 grams of dry plaster per cubic inch.** This means that you multiply your volume by 16.316 (yes, the numbers after the decimal matter) to get the weight of plaster in grams.

$$\frac{100\,ratio\,wt.\,plaster}{70\,ratio\,wt\,water}=\frac{X\,wt.of\,\,plaster}{Y\,wt.\,of\,water}$$

Simplifying the above ratio we get

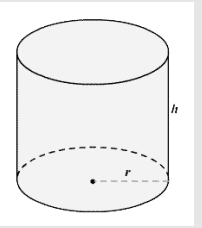
100Y = 70X

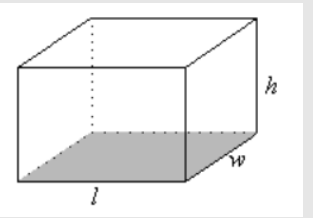
Solving for Y, the weight of water in grams we get

Y = 70/100 X

Y = .7 X

So, from your cubic volume in inches, you determine the weight in grams of your plaster by multiplying by 16.316, and then multiply that by .7 to get the weight of the water in grams.





Cylinders: Cubic Volume - π x Radius^2 x Height

Rectangles: Cubic Volume - Length x Width x Height

EXAMPLES:

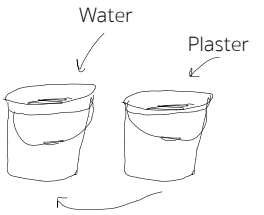
4in x 5in x 2in = 40 in^3
40 x 16.316 = 652g [weight of plaster]
652 x .7 = 456g [weight of water]

6in x 7in x 4in = 168 in^3
168 x 16.316 = 2741g [weight of plaster]
2741 x .7 = 1918g [weight of water]

8in x 5in x 7in = 280 in^3
280 x 16.316 = 4568g [weight of plaster]
4568 x .7 = 3197g [weight of water]

Plaster Mixing

With your calculations complete, re-write the desired amount of water and plaster in grams on the paper by your mold. Get two buckets and take them to the scale. Turn the scale on and remember to tare it with the first bucket on; it should read 0 g, before you start adding the water. Do the same for your second bucket of plaster. As you can see in the diagram to the right, you should slowly add the plaster to the water.



Add plaster slowly into water bucket

• Once the plaster is in the water bucket, set a timer for 2 minutes and wait while the plaster is absorbed into the water.

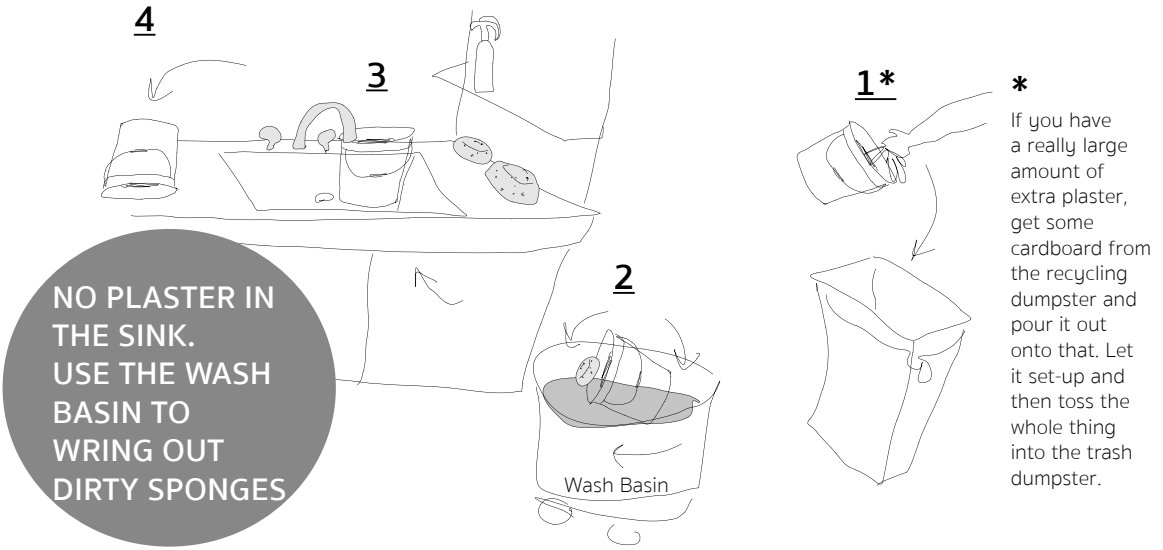
• After the timer goes off, fully submerge your hand in the plaster mixture and use your fingers to break up any clumps your encounter until the entire mixture feels like thick cream. You should mix for about another 2 minutes.

• Pour the plaster mixture into your mold aiming for one of the inner corners so that the flow slowly rises over your model. Knock the table with you palm to dislodge any air bubbles and wait for the plaster to firm up.

Plaster Clean-up

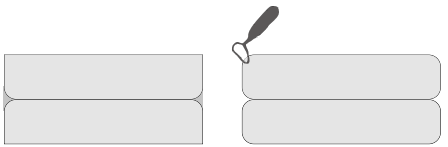
I encourage all of you to work in pairs in the plaster room. You and your partner will each prepare your molds on the same table, do your calculations adding your volumes together, and then measure out a batch of plaster for each of your first mold sections. One partner will pour and agitate the molds to dislodge air bubbles, while the other will clean up. You will then switch roles for the second halves of your molds.

The clean-up process is essential, and it is easier the faster you get to it. Please see the diagram below for the proper process:



1. Using a paper towel wipe out any remaining liquid plaster and place it in the trash.
2. Take a sponge and use it to wash out both buckets in the basin on wheels. Throughout the semester this may fill up with plaster material that will sink to the bottom, so always use the water on the top to rinse with.
3. Only when the buckets look visibly clean can you give them a final rinse with the sink water. ONLY WRING OUT DIRTY SPONGES IN THE BASIN, NOT IN THE SINK.
4. After checking the insides, outsides and bottom place the bucket upside-down on the counter next to the sink to dry. Bring the buckets back to the sculpture area when you are finished.
5. Wipe down your work area with a sponge. It may still be streaky with plaster, so use a spray bottle of water to do a final clean-up after refreshing the sponge in the basin. Keep in mind that this is a shared space, so try to leave it as clean, if not cleaner, than you found it.

Mold Clean-up



When your mold has heated up and starts to cool, take off the cottle-boards and use a scraper tool to shave the hard corners off the edges. The goal is a smooth rounded edge that is less likely to break off while you are handling your molds.

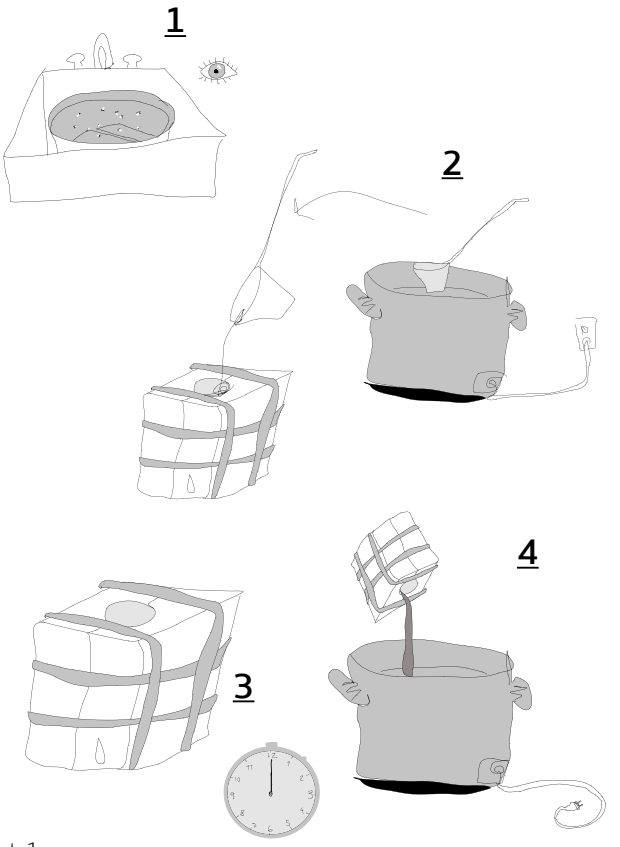
Two-Part Mold Work-flow with a Partner

A. Set up workstation with paper and your two models. Choose cottle-boards for both molds. Build out the base with clay creating a plane along the parting line of the model. Re-attach the cottle-boards, seal up the mold area and brush on the mold release. You should each calculate the volume you will need for your first mold section, then add the totals of water and plaster together, you can always add 10% extra to ensure you will have enough for both.
B. Weigh out the water and plaster in separate buckets, then mix and pour. Whoever is not agitating the molds should clean the buckets.
C. After 15-20 minutes return to the molds and check how they have hardened. They should have gotten hot and then started to cool. Open the cottle-boards, shave off the outer corner and flip over the piece. **Remove the clay. Make sure the model remains exactly where it is.** Check that your plaster is level, you can even out any lumps by shaving them down with a scraping tool.
D. Re-attach the cottle-boards. Re-use some of the clay to seal off the bottom of the mold by placing coils in the corners and along the outside of the parting plane. Apply two more layers of mold release.
E. Calculate the volume you and your partner will need for the second side, they may be the same, but the height could change depending on the model.
D. Switch roles so that you each have a chance to pour and to clean up. 15 - 20 mins. later remove the cottle-boards and clean them up in the basin. Return to clay to its bag in the container. Shave down the second piece's outer corners and put all shavings in the trash.
F. Back in the classroom, pop open the molds and remove your model. Wipe them down to remove any clay on the surface and allow to dry.

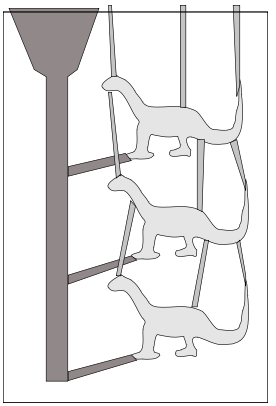
Making a Wax Cast

Once your two-part mold has cured over night, or ideally 48 hours, you can make your first wax casts. Put a bucket in the sink and fill it with water. Carefully place both halves of your mold in the water so they are fully submerged. You will see little bubbles come to the surface like carbonated water. After about 10 mins. the bubbles should stop. At that point you know the mold if fully saturated and therefore the wax will not stick to it. During the time you are soaking the mold, you should plug in the crock-pot and watch the melting wax. It should fully liquefy in 10 mins.. When both your mold and the wax are ready, take the pieces out of the water, pat them dry and then use rubber-bands to connect the two pieces. If you are worried about your seal, you can press a coil of water-clay around the seam.

If you are making a solid cast, all you need to do is fill the mold with wax all the way to the top and wait for it to solidify. If you are making a hollow cast you should fill it up, but then wait somewhere between 5 and 15 mins. for the wax to form a shell about 1/3 in thick before you pour out the remainder of the wax back into the pot.



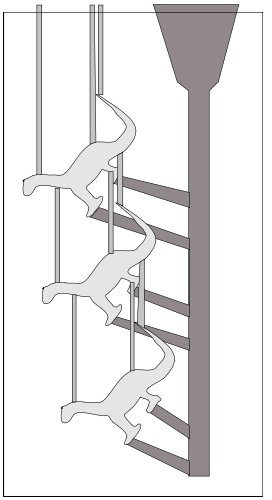
Preparing Wax casts for Investment Molds



For this project, I am asking you to manipulate the wax casts you make after they come out of your mold, and you can do that by either taking wax away from your casts, adding wax to your cast or heating and deforming your casts. I suggest you make more casts than you expect to need so you can practice the various tools and techniques. When you are satisfied with your results, you will need to prepare three of those variations into a wax tree for investment casting.

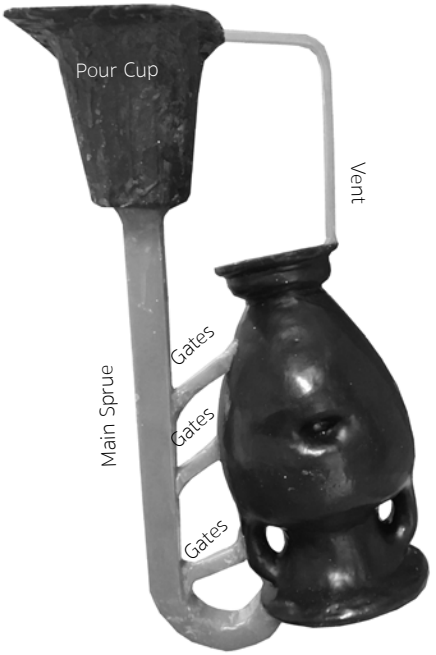
As you can see in the various diagrams, you will be adding a pour cup, a sprue and vent system. It is best to imagine these as veins and arteries: they allow the molten metal to access your models while also allowing air to escape upwards until every possible part has been filled with metal. What you are making in wax, will then be melted out of another mold leaving detailed negative spaces which can then be filled with aluminum.

The ways to design such a system are infinite. I will advise you, but I suggest you start with a few diagrams like the ones on this page. There are two essential principals:



1. Send the metal to the thickest parts of your form first, and

2. Make it extremely easy for the air to escape.



You should also always angle the gates upward toward your model from the main sprue, and place your vents at all the high-points on your form. All of your models should be connected, so you can vent one into the next. Just picture the metal like a rising tide through your mold, and make sure you aren't left with any pockets where the air can't get out.

Cleaning up in the Wax Room

As it is in all our shared spaces, it is essential to know how to properly clean up after you have been working in the wax room. The main tool you will be using is a metal scraper or spatula. Any drips or splats of wax on the counters or floor can be easily scraped up and then the shavings thrown away.

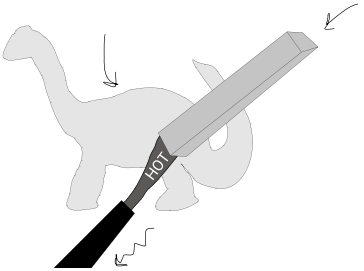
When it comes to the utensils used with the wax - spoons, cups, or ladles - where there is a thick layer of dried wax all over the surface, it is easier to use the heat of the crock-pot to re-melt that wax than to scrape it off by hand. Once the wax in the pot, and the utensils have heated up evenly, you should be able to swish it around and come up with an almost totally clean tool. This is especially important with the ladles and spoons so that they next person can easily fill their molds without spilling.

Manipulating and Connecting Wax Systems

With your wax casts ready, and a diagram for your sprue and vent system in mind, you can begin the wax work in earnest. The keys to wax are, unsurprisingly, heat and fire. You can use small alcohol lamps, candles or a propane torch to heat up your tools and soften the wax. In our wax room we have both brown and red wax. The brown wax is more rigid and picks up the details of castings better, the red wax comes pre-made into lengths of square and round rods and is more elastic, so it is used to form the sprues and vents. **Do not melt red wax into a pot of brown casting wax.**

When you are cleaning up your casting, you can get a lot of work done with a butter knife and a small flame, but you may soon move to small dental tools to both add detail to the surface or burnish up smooth areas. Remember that direct heat on the wax can cause it to fully melt and then drip, so you are better off heating your tool and then applying it to the casting warm so that it manipulates the surface cleanly.

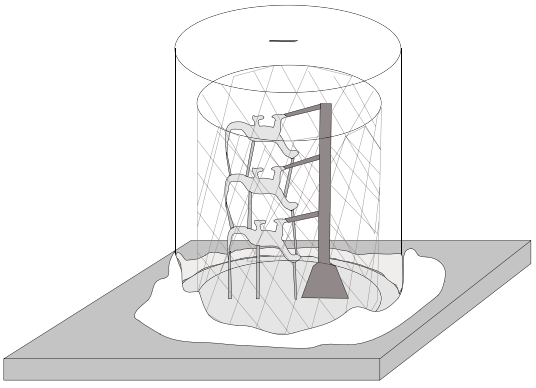
When you are attaching sprues and vents, the most important part is heating up your tool sufficiently. Using a small rounded spatula that you have heated for 8-16 seconds in the torch, place it in between your model and the sprue you are attaching. Apply pressure towards the connection point as you pull out the tool. Continue to apply pressure for at least 30 seconds until the two elements have cooled and hardened together.



REMEMBER THAT YOU ARE WORKING WITH HOT TOOLS AND HOT WAX. BE ATTENTIVE WHEN USING THE TORCH ESPECIALLY IF THERE ARE A NUMBER OF YOU WORKING IN THE SMALL SPACE.

Making a Flask for the Investment Process

The next step on this journey is to make the final mold which will be in direct contact with the molten metal. Because of the extreme situations it will go through, it needs to be made and reinforced in a different way from our previous molds. Happily, with an investment mold, you do not need to worry about undercuts; it will be poured in one piece. Cylindrical molds are often most efficient because of the shape of casting trees, so we will be using tar paper to form the outer support for the mold instead of cottle-boards. About an inch in from the tar paper will be another cylinder of chicken wire. This will keep the mold from cracking in high heat. Your models in the casting tree should sit about 2in inside of the chicken wire. It is important that you have enough space between each of the layers.

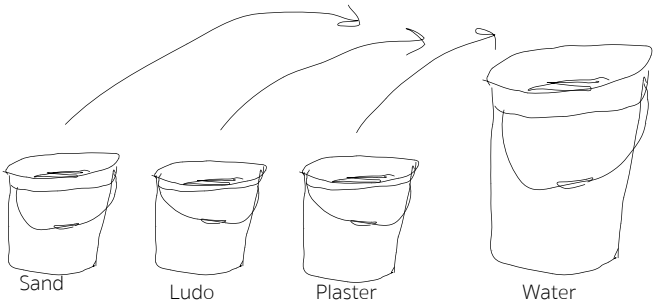


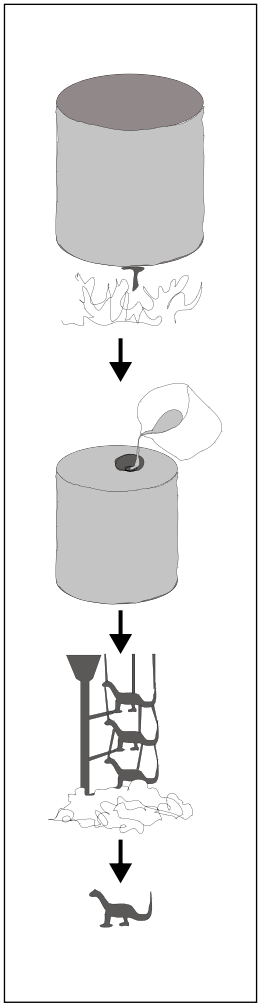
Once you have the materials for each of these layers cut down to the approximate size, set them aside and begin with the base board. Here you will attach your pour cup and vents by heating them and pressing them into the wood. You can add more melted wax around them if you need to. Once that is secure, place the chicken wire and then tar paper. The tar paper should be duck-taped together along the seam and also around the circumference like a belt. You can hold it in place with some tape, but then you will need to mix a small batch of plaster to smear around the edges, fully securing the flask to be filled with investment.

Investing, Drying, Firing, and Pouring Aluminum

Investment molds look similar to plaster molds, but they are made with different materials. The recipe we will be using is a 1:1:1 ratio of plaster, sand and ludo mixed with some water. Ludo is a batch of 50:50 plaster and sand which has already been used to make a metal casting, so it is a material that we can recycle infinitely.

The first part of this process we will be doing is preparing the ludo to be reused. Essentially we need to smash the chunks back into powder and the sift everything so that it is an even fineness. Then we will measure out a few batches of ingredients in buckets like you see in the drawing above. You need to have everything laid out before you start mixing, because you need to move fast once everything is added to the water.





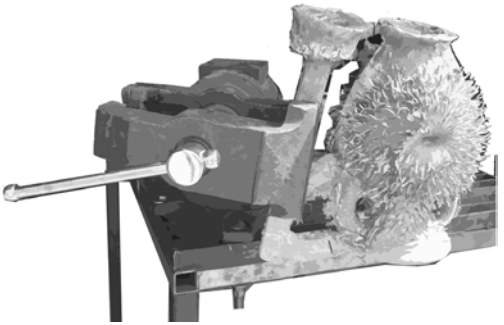
With all the flasks set up in a row we will mix the materials and then pour them down the line until they are all filled. It should take about 20 mins. for the investment to harden, and at that point we can remove the tar paper / plaster and boards. The finished cylinders will dry for a bit outside before we load them upside-down in the gas kiln. We will run the kiln for about 24 hours to slowly heat up and melt all the wax from the insides. When they are cooled, we will move them into the box of sand in the foundry.

Like you can see in the image below, it takes a team to make a metal pour happen. It takes 2-3 hours for the furnace to get the crucible and metal up to temperature, and then two people work together to bring it up and pour the metal into the molds.

This image was taken during an aluminum pour in the fall of 2019. The molds were made with a different process, resin bonded sand, so they look a little different than what we will be doing, but the PPE, and process of pouring the metal will be the same. Two people support the crucible, and there are others in the wings waiting to step in if there are any issues.

Angle Grinder Safety and Use

An angle grinder is a hand-held multi-purpose tool that can cut, grind, smooth and polish metal.

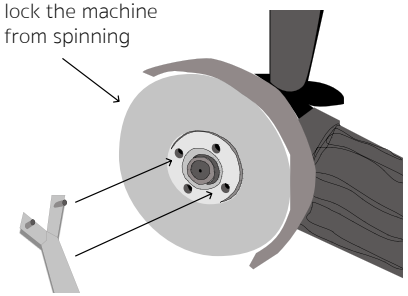


SET-UP:

You must make sure that your piece is clamped down or secured with sandbags before you begin. You can use a bench vise like in the image to the right, or regular c-clamps.

PPE:

While you may want gloves on if your metal object is sharp, you should not wear gloves while operating the tool. As with any rotary tool there is a danger that stray glove or sleeve will get caught while working. Wear safety glasses, face shield, ear plugs and long pants. If you plan to work for an extended period of time I recommend wearing a respirator. Make sure the overhead door is opened and if you can, work outside to allow for air-circulation.



Use adjustable tool to un-screw the plate which holds the various blades in place

When you take the angle grinder from the tool crib it may already have a blade attached. Flat slightly waffled ones are cut off disks, thicker grainier ones are grinding disks and bulkier layered ones are flap-disks. You can purchase fresh disks from the shop technician, which is recommended if you have a big project, otherwise you can use what we have available in the cabinet. ALWAYS MAKE SURE THE TOOL IS UNPLUGGED BEFORE CHANGING A BLADE OR ADJUSTING THE HANDLE AND GUARD.

In order to change the blade, you need to press a small button on the back of the machine head. As you hold it down, you should be able to move the blade manually but only a short way and then it will lock. Still pressing on the button get the adjustable pin tool that will allow you to un-screw the small plate on the front of the tool that holds the blade in place. Make sure it is fully tightened before you release.

Depending on the angle you will need to approach your piece, you may want to switch the side that the handle is screwed into. WHEN YOU CHANGE THE SIDE OF THE HANDLE YOU ALSO MUST ADJUST THE GUARD. On the back side of the guard is a small leaver that you need to press down in order to release the guard to rotate around the tool. It should click back in place when it is aligned in the final position.

When using the tool for cutting off the sprues on your casting tree, use the center of the blade and work slowly applying pressure, but making sure the tool is under your control. If you start to cut with the far sides of the blade you may feel the tool starting to want to 'kick-back' or twist away from your piece. Calmly pull the blade back from the piece and re-adjust your angle. Do not cut deeper that 1/4in.

WHEN YOU ARE WORKING, ALWAYS PLACE THE TOOL UPRIGHT ON THE WORK-SURFACE SO YOU CAN SEE THE BLADE AND THE ON/OFF TRIGGER.

Hold the machine with both hands, one on the body and the trigger and the other on the handle. When grinding down metal approach with a 15˚ angle to the surface.

Cleaning-up an Aluminum Cast

When you have finished cutting your castings off from the sprues, you will probably still need to grind down the surface to make it clean. With small objects, it can help to use an extra glove or rag in the bench vise so that the clamping does not dent or distort your object.

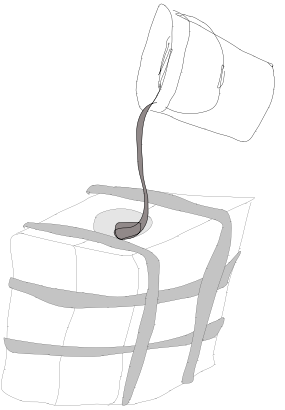
All grinding should be done within 1 inch of the edge of the disk. Approach your surface at a 15° angle and lightly 'kiss' with the outer edge of the disk. As you can see in the images below, grinding will cause sparks, so be prepared and if you need to, please move a shield to protect any of your classmates who may be working near-by.

The final stage of your work will likely be done by hand with cold chisels or with a Dremel tool.

Chisels are used with a hammer to knock off flashing around the casting. As with all of these processes, make sure your piece is properly secured so it does not move while you work.

The Dremel is a much smaller rotary tool that has a great number of attachments to refine the surface and polish your castings.

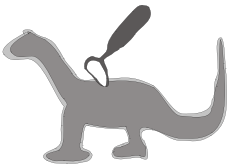
BONUS: Slip-Casting



Using the same two-part plaster mold, you can make castings in other materials such as clay and paper pulp. The preparation for either of these methods is the opposite from what you did for the wax. Instead of ensuring that the mold was wet so that the wax would not dry into the mold, with clay and paper, the mold must be bone dry. In these situations, the plaster is actually absorbing water out of the clay or paper-pulp and that, in turn, causes the solidifying cast to shrink slightly, allowing it to be removed from the mold.

Mix up the casting slip according to instructions. Use rubber bands to wrap your mold and seal the outer parting line with a coil of water based clay if your are worried about possible leaks. Fill the mold all the way to the top of the pour cup with slip.

Depending on the humidity of the day and the temperature, the time you wait will differ. Ideally in 20-30 minutes the clay in contact with plaster mold will have solidified as the water is pulled out of it. You will see that the pour cup area will have shrunk and you should be able to identify the thickness of the casting from what is going on with the pour cup. The thickness on the outside of the mold should be between 1/8 to 1/4 in. Pour out the unnecessary slip. Continue to wait to the cast to set up. Once the pour cup feels leather hard, open up the mold and trim the casting. This will make a hollow cast that can be fired in a kiln and glazed. It is much harder to cast solid in clay using this method.



Project 1

Due on September 21st, 2021

WEEK 2
TUESDAY August 24
Intro to Project 1
DEMO: 2-part Molds
THURSDAY August 26
First group plaster day

WEEK 3
TUESDAY August 31
DEMO: Making a wax cast
DEMO: Oil clay and/or Wax modification techniques
THURSDAY September 2
Second group plaster day
Wax work day

WEEK 4
TUESDAY September 7
DEMO: Wax work for metal casting
THURSDAY September 9
Final Group Plaster / Wax day

WEEK 5
TUESDAY September 14
DEMO: Investment for metal casting
THURSDAY September 16
Group Investment Day

WEEK 6
TUESDAY September 21
Casting Clean-up
THURSDAY September 23
Introduction to Project 2

WEEK 7
TUESDAY September 28
Critique for Project 1

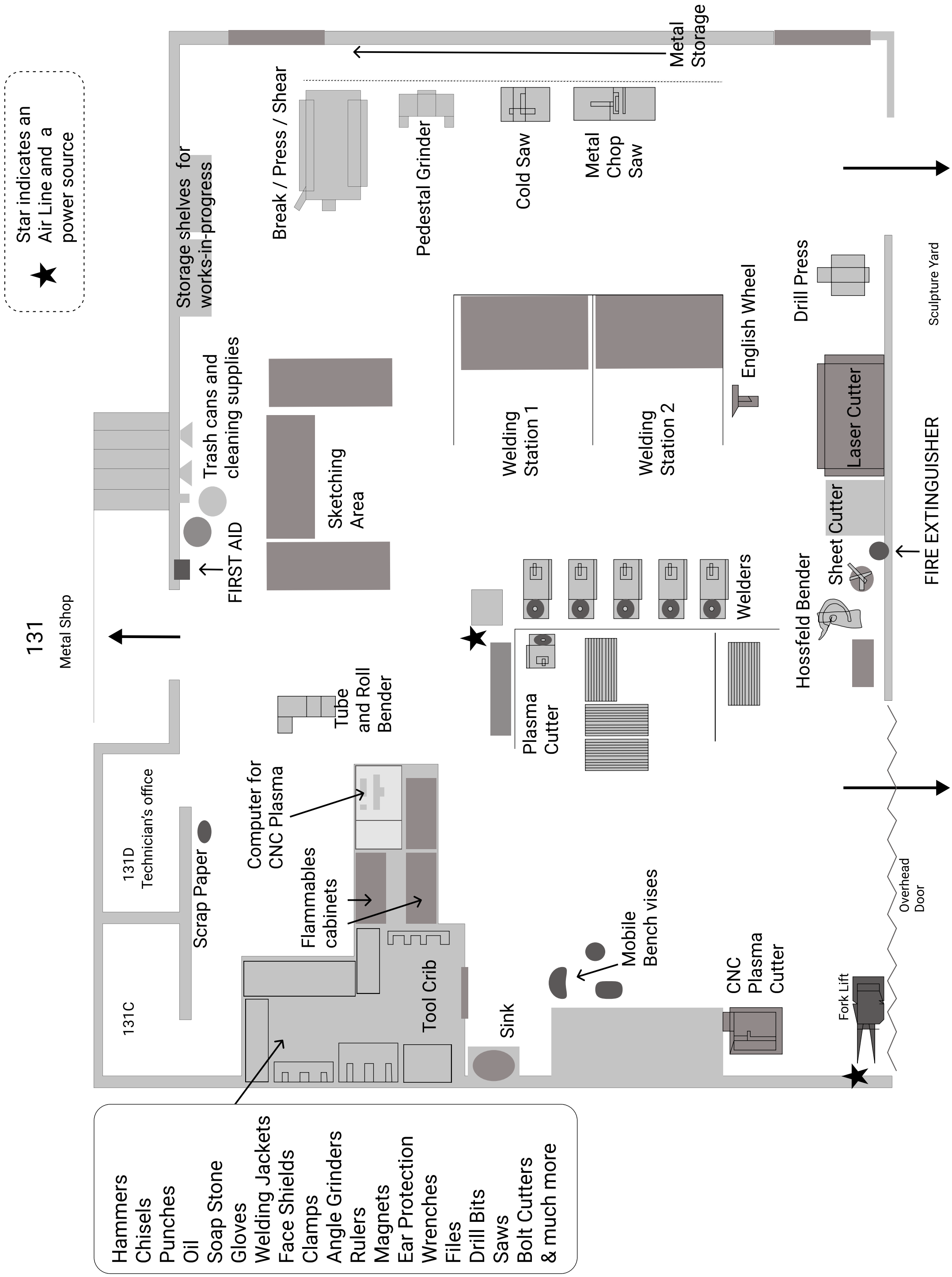
Assignment:
Inspired by a recollection of your childhood, explore the idea of transformation through a group of three cast-aluminum objects. The first piece in the series will be a cast replica of a found toy. The next two will be modified, broken apart, recombined, or in any way altered to evoke both connection and change. How could you capture, say, the growth of a person- the shift in perception from elementary school to now - the distortion of memory. Think about the cultural/historical/personal connections that surround your starting object and how you can make your particular narrative legible to myself and your peers. Thoughtfully consider the visual balance across the series and how they will each engage with the table-top and with each other. As the final material for this project will be the same for each of you, focus on the qualities of the surface texture and the form that can best communicate your specific vision

Considerations:
Many of the plastic objects we interact with are made through a process of Extrusion Blow Molding in which a plastic bubble is expanded to the contours of a two-part mold. This process often leaves the parting-line visible, and so I suggest you use a blown plastic object as your starting place because this line will help you build your own two-part plaster mold.
There is a strict size limit for this project: 3in x 5in x 3in or a comparable volume for each of the three elements.

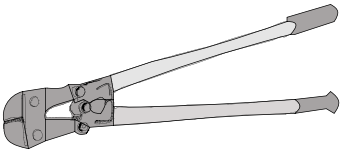
Objectives
Make 2-part plaster molds • cast wax copies and manipulate them • learn to prepare waxes for investment casting • observe an aluminum pour • learn to clean up metal castings for presentation

Artists:
William Kentridge: “Procession,” 1999-2000 Bronze sculptures
Mike Kelley
Genesis Belanger
Sarah Peters

Guide to the Metal Shop



Cutting and Bending Metal Rods



You may be surprised to find out how much steel you can manipulate and cut with just hand tools. We will be working with both 1/4 in and 1/2 in round stock and both of those can be cut with bolt cutters. Anytime you are working in the shop you should have on safety glasses, and you must have them on the cut down your steel. I suggest you measure out all the lengths you need to make and mark them with soap stone directly on the steel. Then with the bottom of the bolt cutters on the floor, slip the steel in between the blades slowly applying pressure with your hand on the top handle. You can then press down on the top handle with your full body weight and the rod should snap in two quite easily. This method is especially useful for thicker round stock.

If you are looking to use bar stock or any kind of square or round tubing in your piece, you will need to use one of our two metal saws.

Metal Chop Saw & Cold Saw

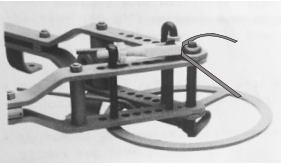
Any thickness of metal that you cannot cut down with the bolt cutters, you can use either the metal chop saw or the cold saw to do so. For either machine, you will need safety glasses, face shield and ear plugs.

The **metal chop saw** is like a cut-off disk on an angle grinder; expect that it will spark during the entire time you are cutting. Using the clamp which it part of the machine setup, align you metal where you want to cut and tighten the clamp in place. The metal should be totally secure before you begin the cut. Start the saw and make sure that you get it up to full speed before you begin to cut. Apply even pressure downwards until you have gone through the thickness of the metal. Slowly raise the blade away from the metal before you let go of the trigger. Wait for the blade to stop moving completely before you un-clamp and remove your metal pieces.

The **cold saw** works in a similar principal, except it uses a fluid to lubricate the blade as it cuts. After clamping in the metal, you will need to open the valve on the fluid a 1/4 turn allowing it to flow over the blade. You can then turn the saw on and slowly bring the blade down and through your material. As with the other saw, pull up out of the material before you let go of the trigger. Once it is off, close the valve and remove your pieces. Clean up by directing fluid down into the catch basin with plastic card and wipe down with a rag. Sweep up metal shavings and throw them away.

Hossfeld Bender & Roll Bender

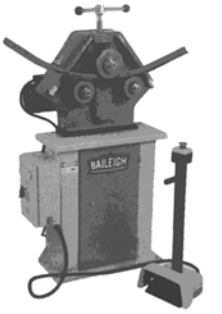
The exact operation of both of these machines will depend greatly on your project, but there are a few preparations you can do to ensure a successful bend.



Hossfeld Bender

Always wear safety glasses when bending.

Plan to have a scale drawing of the curve or curves you would like the make. If you want to make the same curve on multiple steel rods, consider tack welding them together and bending them at the same time. Once all in the final form you can cut off the ends where you welded. This is the only way to get identical copies of the same complex curve.



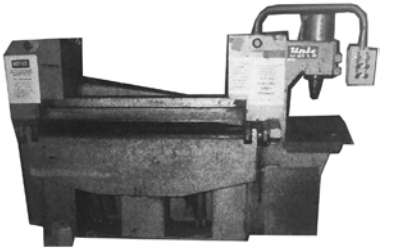
Hydraulic Roll Bender

Cutting and Bending Metal Sheet

	Gauge	Thickness
22	22	.026 in (0.66 mm)
21	21	.028 in (0.71 mm)
20	20	.031 in (0.79 mm)
19	19	.036 in (0.91 mm)
18	18	.040 in (1.02 mm)
16	16	.051 in (1.30 mm)
14	14	.063 in (1.60 mm)
12	12	.079 in (2.01 mm)
10	10	.102 in (2.59 mm)
9	9	.114 in (2.90 mm)

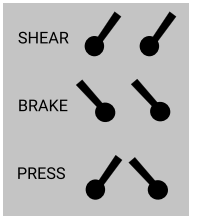
The chart to the left is a good guide for the thickness of sheet metals as well as the thickness of wire. We will be working with 12 or 14 gauge sheet, but if you are using scrap sheet, you may end up with a thicker or thinner gauge which you will need to address with a higher or lower voltage when welding.

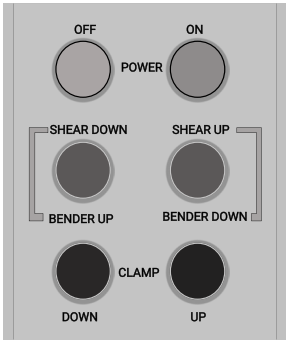
Shear / Break / Press



This machine is the first stop for cutting the large 4 x 8 foot piece of sheet down to a manageable size, but it can also bend or form sheet metal. Wear safety glasses and ear plugs when operating the machine.

On the far right side of the machine you will see a series of levers. Make sure they are in the right position for the operation you wish to do: Shear is for cutting, Brake is for bending, and Press operates the hydraulic hammer on the side of the machine. Notice that the control buttons also shift depending on the machine setting, so double check that everything is where it needs to be before you begin. Once the machine is on, the first step is to raise the clamp, then you can insert you material to be cut or bent. The bending point is at the front end of the clamp and the cut point is about 15 in behind the clamp, at the back edge of the machine center. Lower the clamp making sure the metal is in the correct position. Then you can either lower the Shear until it cuts all the way through your piece, or raise the bender until you have gotten the desired angle in your piece. Return the machine's elements to their original positions before you raise the clamp and remove the metal.





DO NOT ATTEMPT TO CUT OR BEND ANYTHING THICKER THAN 3/16IN THICK, AND ONLY USE FRESH SHEET WITH CLEAN EDGES. USE CAUTION BECAUSE THE EDGES OF FRESH CUT MATERIAL WILL BE SHARP

English Wheel

The English Wheel is a manual metal forming tool that will allow you to take a slightly concave piece of sheet and smooth it out into an evenly curved plane. To begin you need to hammer the sheet in the stump enough to get a solid start on the forming of the concavity. Use the white plastic hammers for this and wear safety glasses and earplugs. The English Wheel has a lower crank for large adjustment and a smaller one for fine adjustment of pressure. Place your sheet between the two rollers at the center of your concavity. Adjust the pressure so that every piece pressed together. Then, with the force of your body move the sheet forward and backward along the rollers. Begin to work the piece to the left and to the right along the outer edges of the concavity. You will be able to smooth and deepen the curve through this motion. Keep working until you are satisfied with the curve, returning to hammer out the deepest areas in the stump before working them out on the wheel.

Basics of Welding

Set Up:

- Plug welder into nearest wall outlet
-Turn on the gas with valve on top, counter-clockwise to open, clockwise to close
- Adjust wire speed and voltage according to the thickness of your metals
- Find a place for your ground clamp either on your work or on a metal table where you are working
- Secure your work with magnets, vices, jigs, clamps, etc.
- Make sure you have a clean work area free of extraneous or flammable objects

When you are finished welding reset speed and voltage to the lowest setting, turn off gas, then pull trigger to bleed the line of gas, turn off welder and unplug, wrapping all the cords and tubes up in a tidy manner.

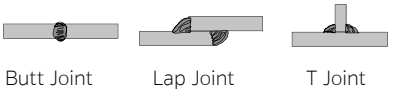
PPE for Welding and Plasma cutting

Closed-toe Shoes
Welding Mask
Leather Gloves
Long Sleeves
Hair tied back
Inflammable Clothes

Proper PPE

Process:

Welding is powered by an electrical circuit. This is why the ground clamp needs to be connected to your piece or a metal table on which your piece rests in order to function. It is also why your weld will be weak if you are too far from the surface of the metal. It is also important to note that the end of the tool is not like a flame, so you can place your gloved hand very close to the tip to get the proper angle and movement you need for the weld.



Butt Joint Lap Joint T Joint

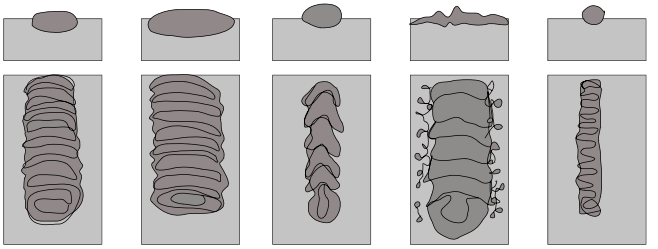
The tool crib has a number of magnetic triangles which are excellent for holding metal rods in place while you weld them together. Usually you do need some form of support to keep your pieces stable while you weld. You should plan for this while you are setting up your station. When you are connecting steel rods at an angle, you should try to weld from more than one side so that the connection is secure.

Ideal movement of welding gun along the seam of two pieces of metal. Imagine sewing them together.

It will feel awkward and bulky at first with all your PPE on, but it just takes practice. Begin with scrap metal and make a few test objects to get the hang of the process before you begin your piece. Beginners often drift away from the metal surface as they weld, so if the sound or quality of the weld changes try to remember to push back towards the piece. Also imagine you are connecting the two pieces of metal as in the diagram to the right: the strongest weld is one where you are melting and connecting the metals into one.

It is also good practice to continuously trim the wire on the tip of your welder to about 1/8in in length before you begin your next weld. If the wire is too long you may have connection problems, or it will cause too much metal to melt and it may clog the welding tip. If the tip is stuck to your piece quickly begin to weld and pull it away. If you cannot dislodge the wire from the tip and it does not advance when you pull the trigger you may need to get help from the monitor or technician.

The sound of a good weld is a peaceful one, not too noisy or crackly, it should sound like bacon calmly frying or white noise on a television.



Normal Bead Ideal penetration and pooling

Too Slow The pool is too large and deep.

Too Fast The pool and penetration are uneven

Voltage is Too High No pooling and too much spatter

Voltage is Too Low Penetration is incomplete, the metals have not bonded

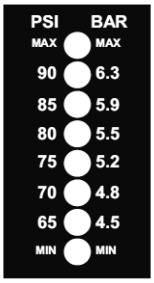
You should always be evaluating your welds and adjusting your settings if anything seems off. Working at too high a voltage and traveling too slowly can cause you to blow through your metal— especially sheet metal— so ask for help if things don't feel right. When mixing metal thicknesses aim for settings closer to the thinner metal to begin with and only shift to more power if necessary.

Cutting Sheet with Plasma Cutter

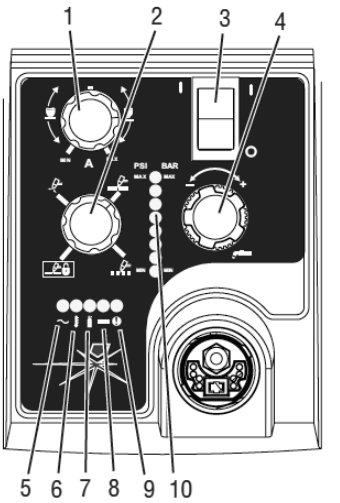
Using the hand-held plasma cutter is very similar to the experience of welding. You should have the same PPE, although you can substitute the welding mask for shaded eye goggles #8 or #9. You should also have your sheet directly attached to the ground clamp, or laid flat on a table that the ground clamp is connect to. The main difference in the set up of the machines is that instead of using a shielding gas, the plasma cutter needs to be connected to an air-line.

The plasma station is therefore usually located around the air-line by the central column of the shop. Wearing safety glasses, turn on the air by unscrewing the valve. Next, bleed the port by twisting the knob on the bottom for 10 seconds. There should not be any water or moisture that comes out. If you notice moisture, ask the monitor or technician for help. If the air comes out dry, you can continue hooking up the air-line to the plasma cutter.

The end of the air-line has a locking attachment which you need to pull back towards you before you connect it to the port on the plasma cutter. With the machine on and the air connected, you should see a pressure registering on the display. It should read 70 PSI. Use the Function Control Knob to select SET if you need to change the PSI. The Output Current Control should always be set at 40 AMPS. With these settings you should be able to easily cut through gauge 12 or 14 steel sheets.



When you are ready to cut, confirm your area is organized and that your table or sheet is connected to the clamp. DO NOT CLAMP CLOSER THAN 10 IN to where you are cutting. Relax and hold the torch at a 90˚ angle from the surface of the sheet. If you draw out your design with soap stone, you will be able to see your lines just ahead of the torch.



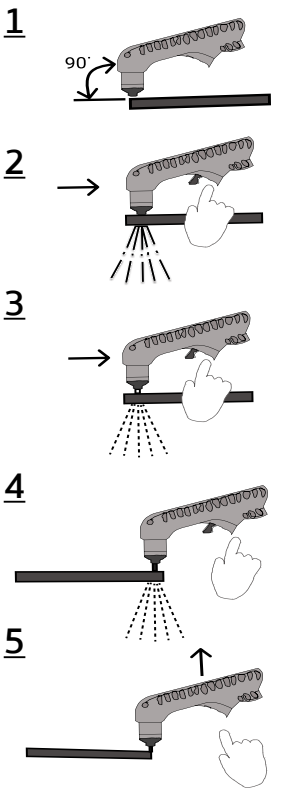
1. Output Current Control
   Should be set to 40 AMPS
2. Function Control
   Begin at SET when adjusting pressure then switch to RUN while cutting
3. ON OFF Power Switch
4. Air Pressure Control (UP is ON and DOWN is OFF)
   Begin with 70PSI
5. AC Indicator
6. Temperature Indicator
   Indicator is normally off, if it comes on turn off unit and allow to cool.
7. Air Indicator
8. DC Indicator
9. Fault Error Indicator
10. Pressure Indicators

We have both Standoff tips and Drag tips for the plasma cutter. Make sure you know which one you are using. For the Standoff tips you should hold the electrode about 1/8in away from the surface of the metal whereas for the Drag tips you can use a non-conductive piece of metal as a guide and literally move the tip directly along the surface of the metal you are cutting.

In either mode of operation, you will need to raise the trigger lock, and then pull the trigger only when you are ready, the arc will begin as soon as you press it. As with welding, you may tend to pull away from your metal which will cause the arc to weaken. If you hear a change in the sound or notice a change in the arc try to push slightly back downward.

Speed is key to clean plasma cutting. Too slow and you will create unnecessary dross, or clumps of molten metal that cools on the bottom of your cut, too fast and you might not actually be cutting all the way through your sheet. You will be able to easily clean up the edges from your cut, but the cleaner it is from the start the faster your next steps will be.

When you are finished, turn off the air valve at the wall, change the Function Control bat to SET and bleed the plasma's air line, and disconnect the main air-line from the back of the machine. You will need to sweep around your area as a lot of slag (molten metal drips) will have accumulated below where you were cutting.



1. Align the electrode with your metal
2. Raise trigger lock, press the trigger
3. Maintain proper distance and move at a steady speed along your cut line
4. At the end of your cut release the trigger
5. Raise the electrode away from the metal surface.

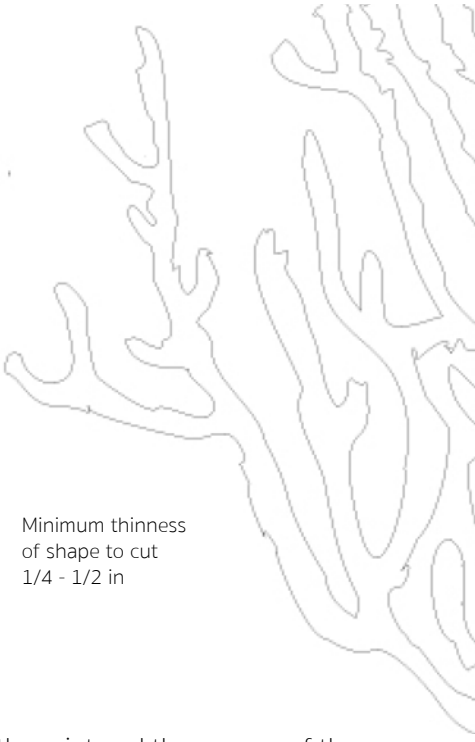
Cutting Sheet with CNC Plasma

The CNC plasma cutter is the same tool, except it is controlled by a computer which can move the electrode in the X and Y axis of a 24 in. square bed.

As with the hand plasma, you must begin by opening, clearing and inspecting the air-line. Because of the location of the CNC plasma, it has its own line by the forklift. You will also notice that the bed of the CNC plasma has water in it. This is to keep the metal cool while it is being cut. You may need to fill up the water as it evaporates a little with each use. Make sure the water level is no lower than 1/4 in below the surface of the cutting bed.

Instead of drawing your desired shape on the metal, you will need to design a vector file on the computer that can then be communicated to the machine.

Preparing a file for CNC Plasma



Minimum thinness of shape to cut 1/4 - 1/2 in

You will probably want to use Adobe Illustrator to create the vector files for plasma CNC projects, but you can also use the free Online software FIGMA if you do not easily have access to the Adobe Suite. When thinking about your project, you should keep in mind from the outset the following parameters:

1. Files must fit within the 24in x 24in print window. While the bed of the machine can accommodate slightly larger sheets of metal, the x-y axes for the machine has that as its limit. Unlike a laser cutter software which will just ignore any lines that exceed the x-y axes, Ucannest will export a file that will be unreadable to the plasma cutter if the path you output goes beyond the margins of a 24in x 24in document.
2. It is also very important to keep in mind that the CNC plasma machine has less accuracy than a laser cutter. At scale, any positive shape you wish to cut should not have elements thinner than the width of a pencil (about 1/4in). Any thinner and you risk it being melted down by the power of the plasma.
3. The thickness of metal you choose to work with will also dramatically effect the issues you may encounter with the print and the success of the translation of your file. 12 or 14 gauge is the best starting point because of their stability.

Once you have a file in Illustrator created with the above parameters in mind, export it as an AutoCAD Interchange File (.dxf). A dialogue box will open with export settings. Make sure you export the file so that it is

a) compatible with the most versions of AutoCAD
b) to scale
c) true color
d) PNG
e) maximum edibility

You should save your file on a flash drive and bring it over to the computer in the metal shop cabinet with Ucannest, the CNC plasma specific software.

When you first open the Ucannest software on the shop's computer you may (or may not) get an error message about the layout. Make sure that the size of the canvas is listed as 24in x 24in before you attempt to import your .dxf file. Go to the File menu and select Import. You will then open the folder where you stored your file. You may find that not all files are visible because the program is only showing files with a certain extension. Click the drop-down menu and select .dxf and your file should appear. Once you import the file it will appear attached to your cursor on the canvas as a large blue square which you click to place in the program.

Processing vector file in Ucannest

The first thing you must do process your file to send to the CNC plasma is to set the path. Selecting your full file, under the Path drop-down menu select Auto Path. A dialogue box will pop up and you should not need to modify anything. Once you become more expert at this process, you may choose to change these settings, but for now the default is a great place to start. The line of your drawing should change from blue to red. After processing the lines through the Auto Path you can move on to Path Output. Under the Path drop down menu select Path Output. When the dialogue box pops open, select Point A from the menu. You should also create a file name and browse where the program should store the file. You should save it directly to the Storeandgo USB. Once you press save, it will seem as if nothing happened, but it did save.

Running the CNC Plasma Machine

First, address the obvious personal safety measures related to the sparks produced once the machine is cutting. Wear a welding jacket, shade 5 goggles, and earplugs. You may also consider a mask and make sure that the monitor has opened the garage door fully. You will want to make sure the yellow shield is in place to protect the eyes of your classmates.

Beyond the safety of all the humans nearby, you also need to consider the safe running of the machine. Check that the water level is about 1/4 from the top of the grid. Place and ground your metal before you begin the test print and try to align it so it sits as flat as possible. You can now turn on the 'brain' of the machine which is the tan box located on the lower shelf. You will use the controller to navigate. Plug in the Storeandgo and press the RUN/PAUSE/DELETE button. Select U Disk File and the green OK button. You will now see a list of files. Use the 1 and 5 to navigate, keeping in mind that the list is a loop so the quickest way to your file may be to go upwards to the end of the list first.

Once you press OK at your file you will see a menu for settings. If you need to change the Processing Speed because the person before you was cutting a very different thickness of metal, press and hold the RUN/PAUSE/DELETE and then press the HIGH/LOW 0 button. You should then be able to edit the number by using the number buttons before pressing OK to save. You should not need to change anything else.

12 gauge metal : AMP 40; Speed 2,670 (mm/min)
14 Gauge metal : AMP 40; Speed 4,830 (mm/min)

Once you press the green OK button again it will process the file and begin moving the head. At this stage, the plasma head should be about 1/2 inch off the metal. You should run through the file and make sure that during the cutting the head does not get too close to the ground clamp. It may also be useful to time out how long the cut takes. This dry run is essential to prevent any collisions between the head any part of the metal sheet or clamp.

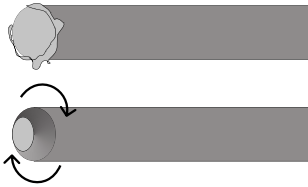
Once you feel comfortable with your test run you can adjust the head so that it is about the thickness of the metal away from the sheet- about a 1/8in. You can then turn on the 'body' of the machine. In addition to the switch, you will also need to make sure the air pressure valve is open WEAR SAFETY GLASSES or ask the monitor to make sure it is done properly. Once the machine registers full air pressure (approx. 65 PSI), and you have all personal, community and machine safety measures in place you can reset the brain to make the live cut. You must be paying full attention during the live cut to make sure that no piece of metal cut out dips up or becomes dislodged in such away that it may catch the head as it moves. If you see this happening you can pause the cut, put on a glove and take pliers to remove the piece. You can then safely resume.

Finishing Metal

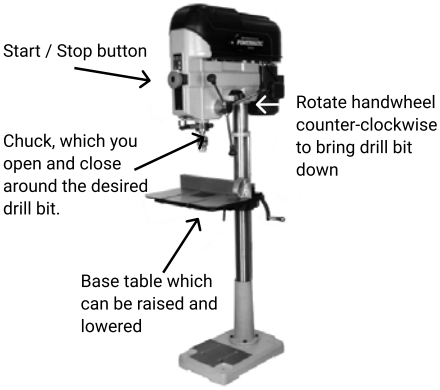
There are a few machines around the shop that will help you clean up and finalize your work. First is the pedestal grinder, which is located by the Shear /Break / Press machine. It is great at cleaning up the ends of metal rods. When you cut down steel with the bolt cutters, you will not get a straight cut, the same is true with the metal chop saw. It can greatly increase the strength and accuracy of your work if you bevel the ends of your rods like the picture to the right. Using the left side of the pedestal grinder, approach with your rod at a 45˚ angle and gently kiss the surface of the grinder with the metal while rotating. This will leave you with a flat bottom and space to make really strong welds around the outside.

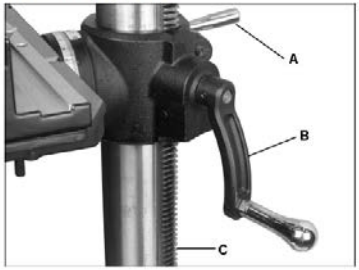
Pedestal Grinder

The drill press might also be a machine you use to finalize your work because it allows you to make clean holes for external hardware attachments. Wear safety glasses, face shield and ear plugs while you work. You will need to get a metal punch and hammer, as well as some oil from the tool crib. Determine where you want your first hole and tap the punch over it with the hammer. This small dent is all the drill bit needs to begin biting into the metal. Once you piece is clamped in place and the drill bit is inserted and aligned correctly place a few drips of oil in around the dent. Turn the machine on and slowly bring the bit into the dent. Continue adding oil if you notice any smoke or a change in sound. Apply even pressure going in and out. Always remove and clean the drill bits before you leave the area. Do not over-tighten the chuck as it can make it difficult to remove the bits.



Holding the rod at a 45˚ angle to the far left side of the grinding disk you can quickly rotate it around to clean up the edges of the rod and make it ideal for welding.





- Loosen column locking handle (A).
- Turn table elevating handle (B) to raise or lower table along the column (C).
- Re-ighten locking handle (A) before attempting to drill

Angle Grinder with Grinding wheel and/or flap disk

Shop Clean-up

The key to a clean and safe shop is everyone cleaning up after each stage of their work. When you are using the broom or dust pan, make sure that you are wearing eye protection and a mask to protect against dust particulates. We have several spray bottles labeled Simple Green, and those can be used with a paper towel or rags to wipe down any oil or to clean off residue on your metal. When you are welding or plasma cutting, you may not notice all the small flecks of metal, but once you start to sweep around your area, you will be able to tell the difference. ALWAYS CLEAN UP BEFORE YOU MOVE ON TO YOUR NEXT TASK

Project 2

Due on OCTOBER 26th, 2021

WEEK 6
THURSDAY September 23
Introduction to Project 2
Tour of Metal Shop
DEMO: Cutting and bending metal

WEEK 7
TUESDAY September 28
Critique for Project 1
Review of sketches for project 2
THURSDAY September 30
Fall Break - No class

WEEK 8
TUESDAY October 5
DEMO: Welding
DEMO: Plasma Cutter
THURSDAY October 7
DEMO: CNC plasma cutter
DEMO: Finishing metal

WEEK 9
TUESDAY October 12
Open work-day
THURSDAY October 14
Open work-day

WEEK 10
TUESDAY October 19
Open work-day
THURSDAY October 21
Open work-day

WEEK 11
TUESDAY October 26
Critique for Project 2

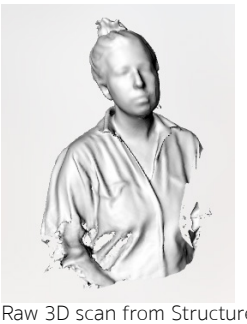
Assignment:
Create a temporary site-specific sculpture / installation using sheets of steel and round stock that maps out, distorts or re-imagines a space within or around the Art & Architecture Building. Exploit balance, texture, line, mark, weight and gesture to help the viewer experience your perspective. Recycle, repeat, or abstract one texture, pattern or form from your space and translate it into the steel. You must blend the two kinds of steel: the linear rods, which can define volume and replicate the built environment and the sheet, which can carry layers of texture, echo organic forms and create planes.

Considerations:
What aspects of the location stand out? What happens there? What are the physical properties of the location? Which of your senses are most activated by this space? Do any of these observations change with the time of day?
How might you respond to the existing movement patterns of the space? How might you respond to the existing light patterns within the space?
How might you respond to the architectural structure/details of the space? Or to the plants and hardscaping?
Projects must not impede safe pedestrian or wheelchair traffic and they may not block a fire exit or entrance or damage any part of the facilities or grounds.
NOTE: Work location must be approved by instructor. You must fill out an orange tag for your work before you install.

Objectives
Design a paper and cardboard maquette • learn to cut, bend, weld and finish steel round stock • use sheet for either hand plasma cutting or CNC plasma cutting • install the final piece in situ inside or around the Art & Architecture building

Artists:
Christo, Lydia Okumura, Peter Randall Page, Andy Goldsworthy, Daniel Arsham, Juliana Santacruz, Richard Vivenzio, Dewitt Godfrey, Tony Hepburn, Diana Cooper, Sarah Sze, Shinique Smith, Louise Bourgeois

Introduction to 3D Models



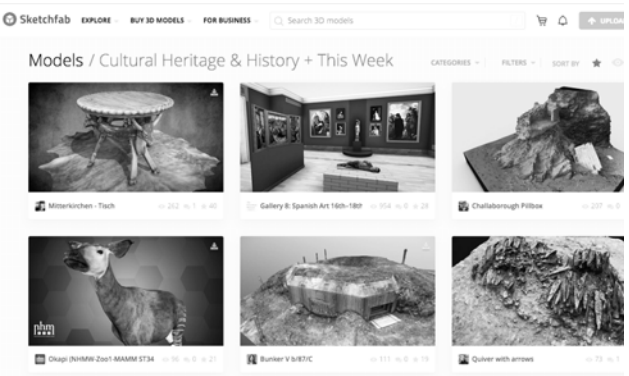
Raw 3D scan from Structure Scanner Sensor connected to an iPad

The first part of this project is going to be selecting or making a 3d file which you will then manipulate and expand in various media. You can find many different kinds of 3D files Online or you can use the iPad scanner to scan parts of your body, or the two scanners in the School of Art Makerspace to scan small objects below about 10 inches in height and width. You can work with 3D scans in many different kinds of software. I will be showing you how to use Meshmixer and Slicer, which are both free to download for Mac and PC. You will need to have access to a computer in order to work in these programs during class, and during homework time. If you need to check out a laptop from the media pool, please make sure that you do so before class time, and let me know if you have any questions or issues related to access to the computer.

There are two different file types related to 3D scans: .obj and .stl

A .obj file carries with it color and texture information about the surface of the scan, while a .stl file is just the geometry of the form that you scanned. For this class, we will be focusing on using .stl files.

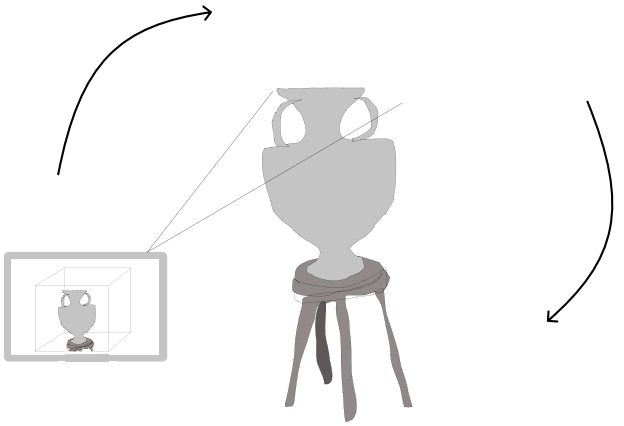
www.ThreeDScans.com



https://sketchfab.com/3d-models/categories/cultural-heritage-history

There are lots of online libraries for 3D scans, and many of them allow you to download .stl files for free. I recommend both ThreeDScans.com and Sketchfab as places to start. ThreeDScans is a project run by a contemporary artist, Oliver Laric, and it has a very interesting assortment of files that you can work from. Sketchfab has a huge selection, so you might want to select their Cultural Heritage and History category which includes collections of scanned artifacts from museums all around the world. I suggest you build up a folder on your computer with models that you are interested in. They will download with very generic names, so it is best to rename the files with descriptive titles to help you once you start combining and mixing them with the Meshmixer software.

3D Scanning



When using the Structure Scanner connected to the iPad, you'll need to make sure that your model, whether that is a person or an object, is stationary. The background can be simple or varied, but it helps if it contrasts in color or pattern from the model. When you begin opening the scanning app on the iPad, there will be a cube that will indicate the scanning area, and it will allow you to pinch in or pinch out in order to change the size of that cube. Once that is set, you can begin scanning. As you move around the model, you will see that a white surface will begin to show up on the model, and as you finish your first circuit around the outside of the model, you should see almost everything overlayed with an off white and gray surface. This allows your to see any holes in your scan, and you can continue to re-scan the model as much as you want. You may want to go above and potentially around the bottom of whatever model you're scanning in order to fill in the full geometry of the piece. Once that's finished, you can save the file and send it to yourself through email on the iPad. Back at your computer you can then download that file to work with in Meshmixer.

Basics of Meshmixer

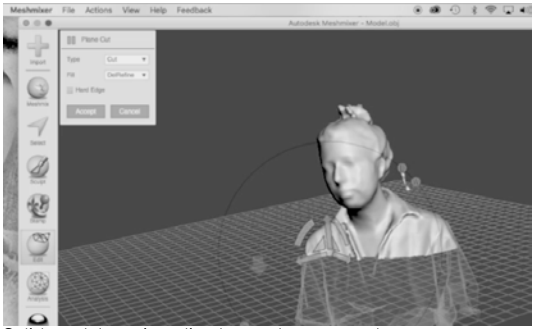
When you open Meshmixer, you will be importing a .stl or .obj file. Press the 'plus-sign' import button and select the file from your computer. The file should render in the view-port and you should be able now to navigate in three dimensions, pressing down the ALT/OPTION key and using your cursor to rotate the object.

In the edit panel you can chose 'make solid' which will take the mesh from a shell to a solid form. Next, also in the edit menu you can select 'plane-cut' which will allow you to draw a line with your cursor and anything above or below that line will be removed. You can edit the angle and direction of the cut before you save and the changes are applied to your model. You can also use the SELECT tools to delete extraneous elements in your file.

If you're interested in blending, sculpting, manipulating or in any way digitally combining your scanned objects, I suggest looking online at the Meshmixer user manual:

http://help.autodesk.com/view/MSHMXR/2019/ENU/

Raw scan getting turned into a solid model.



Solid model getting sliced to make an even base.

School of Art 3D Makerspace

Location:
Art + Architecture 450

Lab Hours:

Please Note: We will not be able to accommodate starting prints or scans at the time of close. Please arrive 30 minutes before to allow time to complete projects.
Students are now able to schedule time with lab monitors for workshops and assistance with print.

Equipment:

2 MakerBot Replicator 2s that can print up to 9" x 6" x 6" in ABS or PLA plastic

4 Zortrax M200s that can print up to 8" x 8" x 7" in ABS plastic, and 1 Zortrax M300

1 MakerBot Digitizer 3D Scanner

1 NextEngine 3D Scanner

1 Structure Scanner Sensor connected to an iPad

Workshops Include:

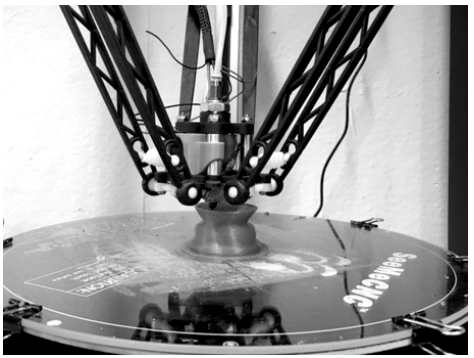
- 3D Desktop Scanner Workshop
- iPad scanner Workshop
- Printing with the SeeMeCNC Printer
- Rhino or Meshmixer Workshop
- How to get a scan ready for printing
- Printing with a Makerbot Replicator 2
- Printing with Zotrax M200/M300
- Vinyl Cutter

The School of Art has its own Makerspace that you can access through my class. If you are interested you can plan to 3D print elements of your final project in PLA plastic.

You will need to provide the Makerspace technician with a .stl file that you have already cleaned up in Meshmixer. You should know the final dimensions for your project, and make sure that it will fit within the print-bed dimensions of the available printers.

You can cut up a 3D file into multiple small pieces that you can print separately and assemble later to increase the scale. You can also make a multi-part plaster mold to slip-cast a 3D printed object in clay. There are many exciting options for integrating these 3D printed elements into your final mixed-media sculpture.

Do not hesitate to reach out to the technicians to ask questions and sign-up for a time to learn a new digital fabrication skill.



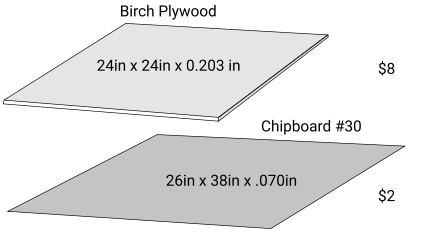
Contact:
soa3dprintlab@utk.edu

Sign-up Online:
https://outlook.office365.com/owa/calendar/SoA3DPrintLab1@live.utk.edu/bookings/

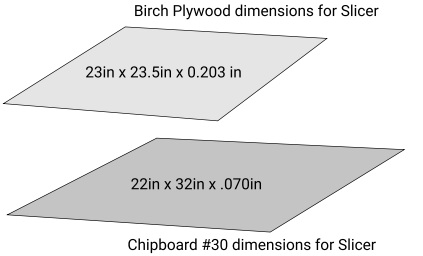
Basics of Slicer

After cleaning up your scan or 3D files in Meshmixer, you should export a .stl file that you will then open in Slicer. Slicer is program that allows you to try out different ways of rendering your 3D model with physical materials like plywood and cardboard. It is important that you follow the steps in the image below so that you can experiment with the full range of possibilities.

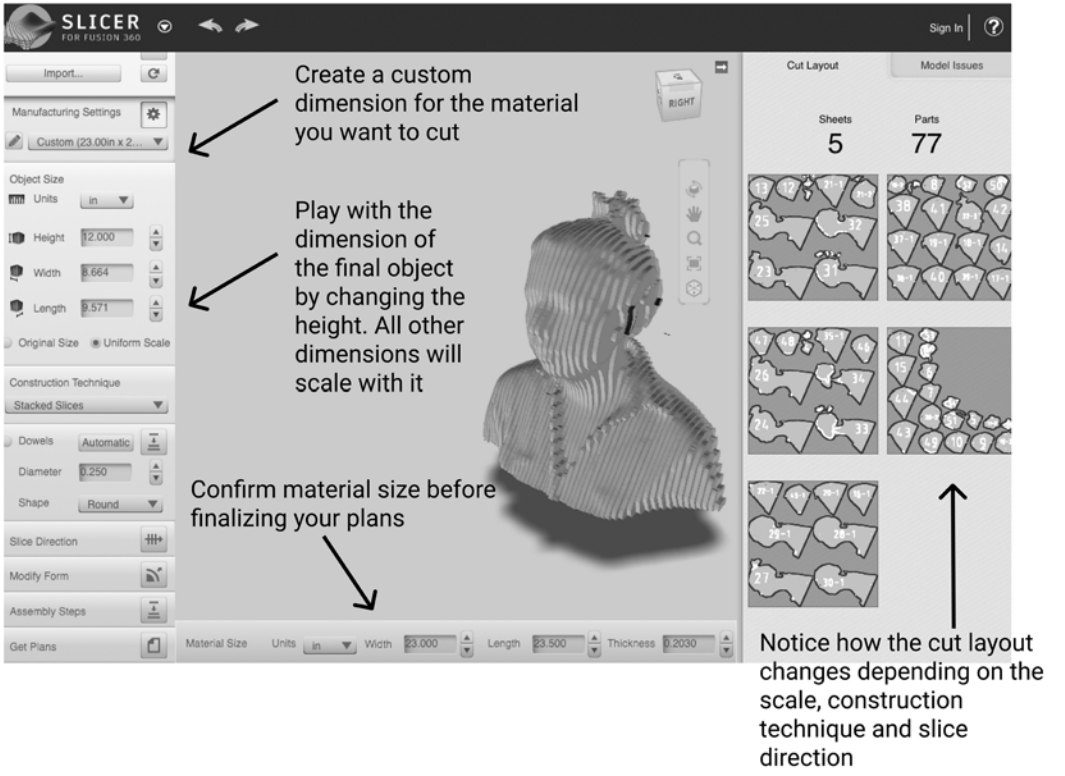
The two materials that you can have cut in the laser cutter are birch plywood and chipboard. Use the dimensions in the diagram to the right as the 'material dimensions' in Slicer. You can then pick various final object dimensions. I suggest just working from the height, the program will scale the other dimensions accordingly. The most unique process is to change the construction technique. We will be using stacked slices, interlocking slices, and radial slices. The most dramatic change can occur when you change the slice direction, so make sure to try both vertical, horizontal and angled directions for your slices.



These are the raw material dimensions, they are slightly larger than the cut area dimensions



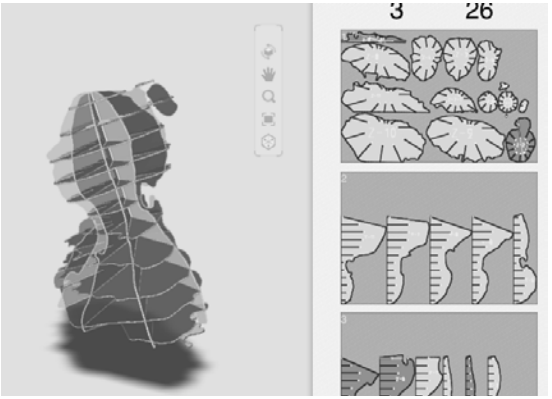
These are the cut area dimensions which you should input into slicer.



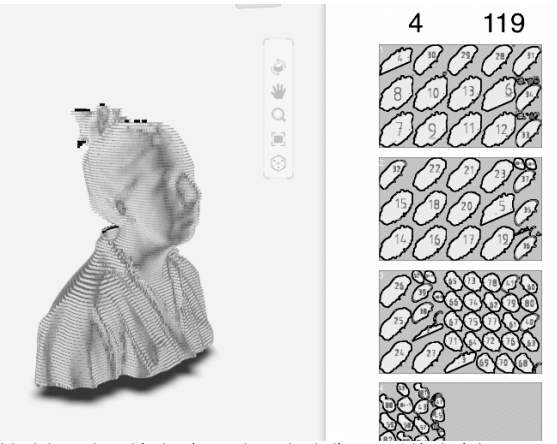
You can see that the two main rendering types correspond generally to the two different materials: The stacked slices are solid and usually rendered in wood, whereas the interlocking and radial slices are more like waffles and are rendered in chipboard. But this is not a rule. Indeed, if you are interested in making the scale of your work much larger than the print bed, you can use this software to make a blueprint for slices that you would cut with a jig or band saw out of much thicker plywood, dense foam or Plexiglas. To do this, you will just need to measure your target material and add a new setting in your menu for it. The program will then output the slices at that scale. You can use the Studio at Hoges Library for affordable large scale printing, and after you glue the plans onto your material you can cut them out by hand.

If you stick with the material size that can be cut in the laser cutter, you will notice that you need to shift the scale of the model depending on the way that it is rendered. The waffle forms can be cut at a much larger scale, because they use less material than the stacked forms. We will discuss as a class what the final material limits for this part of the project will be, but you can assume that the waffled form can be life-size or larger, where are the stacked wood forms will me 2/3 scale or smaller. As you can see in the images to the side, playing around with all of these settings, you'll be able to see how many sheets, the rendering method will output on. This will also affect the amount of time you'll need on the laser.

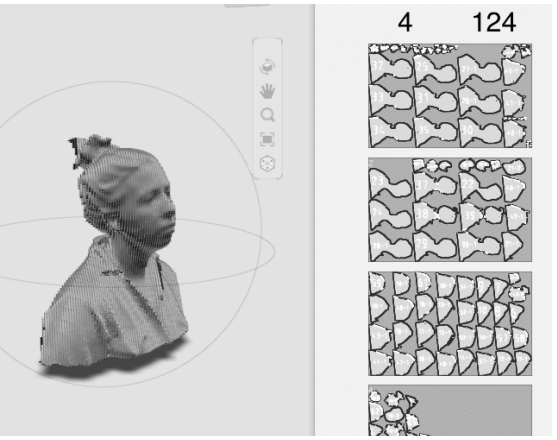
The thickness of the material is really important, so make sure that you input it with as much precision as possible. Because the waffles interlock like a puzzle if you input the wrong dimension they will not connect, and with the stacked form, a shift in dimension will cause a distortion in the model. Part of this project is navigating the challenges and innovations that can come from working in both the digital and the physical space, so be prepared to allow yourself to accept mistakes and challenges, you are going to learn so much from both successes and failures. It is also important to keep in mind that this process is just the first step, and can essentially be the scaffold or base layer for much more manipulation in other media on the surface.



Model rendered in radial slices at 18in. Height. Notice the number and scale of the slices and try to imagine this as the skeleton for your final sculpture.



Model rendered in horizontal stacked slices at 10in height. Notice the necessary scale shift because this piece will be solid wood. It has many parts, but the resolution is low.



Model rendered in vertical slices at 10in. height. Notice the difference it makes in the resolution of the eyes and nose when the slice angle is changed.

Editing Slicer Files in Adobe Illustrator

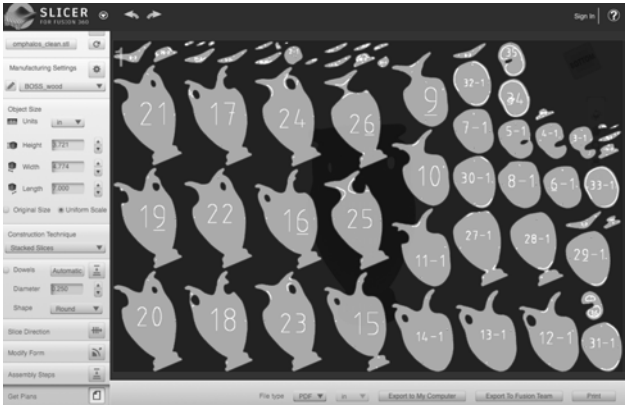
When you have your final plan in Slicer, you can export the layout files as a multi-page PDF. Slicer is a computer program, so it does its best to arrange the shapes to be cut in an efficient manner, but it is not as smart as a human. Because of that, I often re-edit these files in Adobe Illustrator to make sure that I am not wasting material and that the processes is a efficient as possible.

The key process in Illustrator is to transform this PDF into a vector line drawing. You do so by creating a new file, and this file should be the cut size area of the laser cutter in millimeters. Then you should go to the file menu and place the first page of your PDF. Select live trace from the side menu and use the technical drawing setting to render it into a vector line.

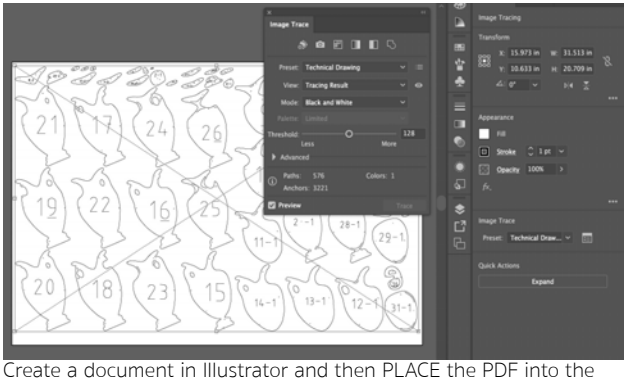
You can use the advanced setting panel when you do the live trace to change the mode or adjust certain factors if you notice that it lost some of the lines from the original. When you are happy with the preview, make the trace.
In the 'quick actions' panel to the right, click expand. Once it is expanded you can ungroup all of the curves. Now, you can select each section with you cursor and rearrange them on the page to make them more efficient.

Once you have done what you can to move the elements to save space, you should also go in and select all the numbers and registration marks for each of your pieces and change the color from black to red. This will allow us to cut these at a lower power so they will not go all the way through your material, but will essentially be drawn onto it.

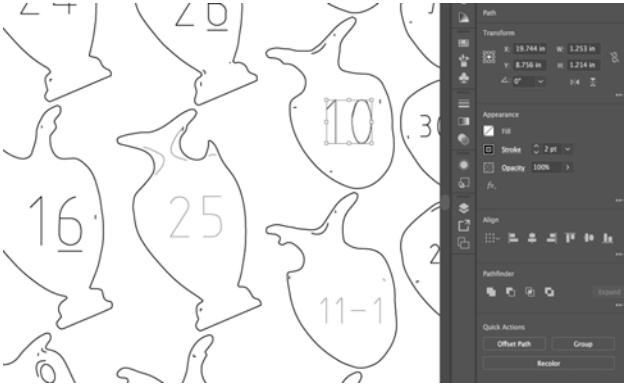
The final step for your file is to change all the line thicknesses to 0.001 in. This can now be exported as a .DXF file which is what you need to process the file in RDWorks to send to the laser cutter.



In Slicer, click on the 'Get plans' panel and export at a PDF to your computer.

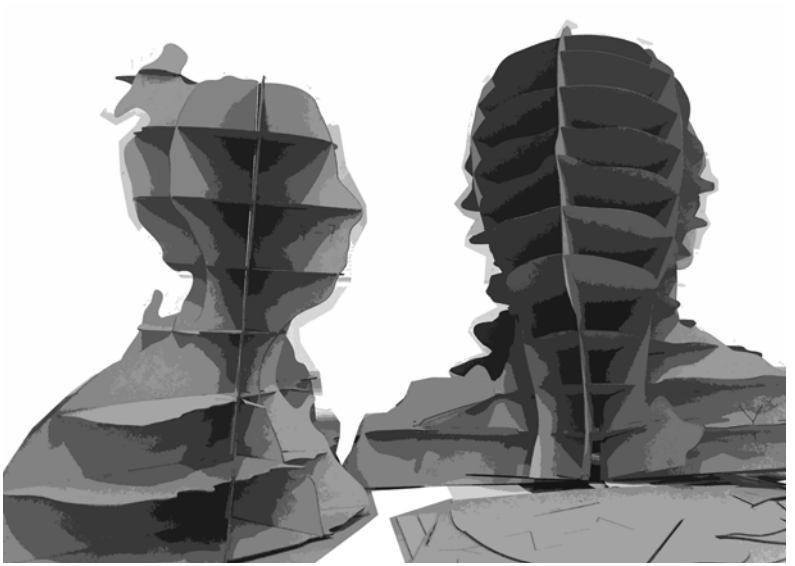


Create a document in Illustrator and then PLACE the PDF into the document. Use the Live Trace with the Technical Drawing setting.



After using the 'quick action' to EXPAND the vectors, UNGROUP them and then begin to select the numbers and registration marks to change the line color from black to red

Assembling materials cut in the Laser Cutter



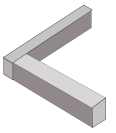
Once your materials have been cut on the laser cutter, you will have a pile of pieces and lots of negative space left-overs of the material. I suggest you begin by removing all the elements from each sheet of material and organize them by number. Slicer labels each part of a stack and each of the horizontal and vertical elements of a waffle. You will probably throw away the remainders of the material, but it is possible that you could use it as filler, or for some other element of your piece, so keep it around just in case.

With all of the elements in order you can begin the assembly. Slicer has an additional menu which allows you to watch a short video illustrating the placement of each of the elements. You should follow this process. It is especially important when assembling the radial sliced waffle forms. With the chipboard you will just be interlocking elements. You may want to have some tape handy, but other that it should be totally self supporting. With the plywood stacks I suggest you do a test layout of the full piece before you get out any glue or clamps. You should also have cut into your pieces registration lines which are curves that show the placement of each piece on the next. They will make a huge difference in the final result, so pay attention.

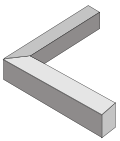
Once you feel comfortable with the assembly, you can set up an area to begin gluing up the slices. You will want a thin even layer of glue and clamps on at least two points to ensure you have a permanent connection. It may help to break up the form into thirds and tackle each section individually before gluing the whole thing together. This will take time, but you do not want to rush it otherwise it can turn into a big sticky mess.

From this point, your models are essentially the skeleton or the starting point for the rest of your sculpture. You can add material to the inside, you can add material on the outside. You can do any other kinds of mixed media things that you wish to do with the model.

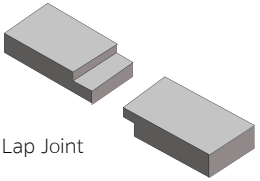
Basics of Wood Joinery



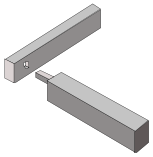
Butt Joint



Mitered butt Joint



Lap Joint



Mortise and tenon

Wood joinery is a branch of carpentry where you cut the wood to form special connection points that are held together alone or with glue. The Butt joint is the simplest connection point, but it is also the weakest. When you are making 90˚ corners, consider using the chop saw to cut a 45˚ angle on both pieces to make a mitered butt joint. With glue and a few nails, this will be a much stronger and cleaner edge.

Lap joints are a great way to bridge material without distracting overlaps. Use hand saws to cut away half the thickness on each end and use glue and small nails to finalize the joint. Mortise and tenon joints are a simple and attractive way to connect pieces of wood without additional hardware. A true tenon is carved from the wood, but you can also approximate it by drilling and gluing a dowel in place. A hole is then drilled in the other piece of wood and the dowel is glued and clamped in place. Once sanded the connection is almost invisible and entirely made with wood.

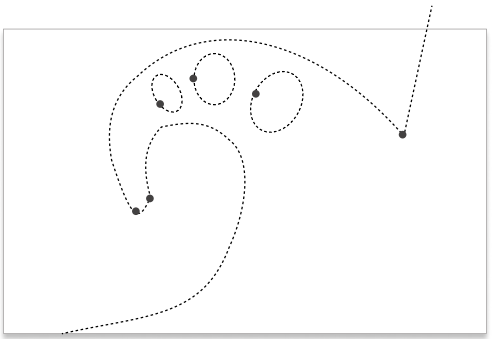
Hand Tools

In the 129 classroom we have a number of tools that will help you combine, manipulate and finalize your mixed-media sculptures.

ANGLE GRINDER: With a range of attachments meant for grinding wood, you can use the angle grinder in the same manor and with the same PPE (safety glasses, face shield, N95 Mask, and earplugs) as you did in the metal shop. We also have additional smaller pneumatic tools (which run with the air-line) which can gouge and sand any piece of solid wood (or plywood stack from the laser-cutter).

CORDLESS DRILLS AND DRIVERS: In the cabinet by the chop saw, we have a number of cordless drills and smaller cordless drivers. A drill can have either bits for drilling holes, or flathead or Phillips head bits for screwing in hardware. The driver can only house bits for screwing and unscrewing. If you are working on a large fabrication project it can be helpful to have one of each so that you can, for example, drill your pilot holes, then screw in your screws without having the change the bits on a single machine.

JIG SAW: This saw is hand-held and allows you to create complex curves with plywood. In the set up for the jig saw, clamping down your material is key. Using saw horses, or placing your wood between two tables, make sure it is secured in at least three points with c-clamps. You can use a drill with a 1/2 in. bit to drill starting holes, or holes along the curve where the saw will need to change directions dramatically. You can slip the blade into these holes and move into the wood at different angles. This technique will also allow you to make cut-outs within the form.



Sample cut line for a jig saw with the dots being the drill holes that allow the blade access at better angles.

Power Tools for Working in Wood

We have a number of power tools that you should feel comfortable using and able to use for elements of this project.

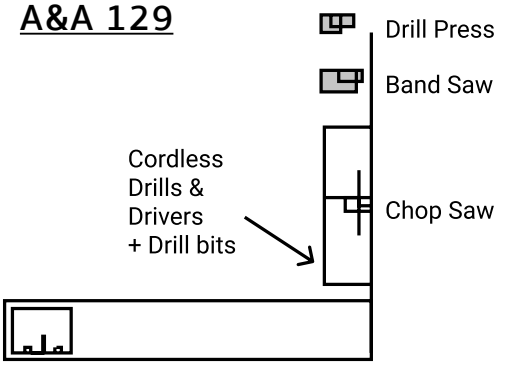
The first is a **chop saw** which is used for cutting down pieces of dimensional lumber, or anything that is too thick or cumbersome to cut with a handsaw. You can cut at a 90˚ angle, but you can also change that to miter wood for corner joints. Begin by measuring out your first cut and checking the alignment with the blade. Make sure you're following safety guidelines and wear safety goggles, earplugs and an N95 particulate mask. You should sweep up all of the sawdust and place leftover fragments to the scrap bin.

Using an angle grinder to sculpt stacked slices of laser cut plywood.

The **band saw** is great for cutting curves out of plywood. You should first adjust the vertical guard along the blade. Raise and lower it depending on the height of the piece of wood that you are cutting. You may also need to adjust the guide on the cutting table. If you're doing curved cuts to turn a rectangle into an oval or a circle or some kind polygon, you will want to put the table guide as far away from a blade as possible so you have the widest area to maneuver your wood. DO NOT PUT YOUR FINGERS NEAR THE BLADE. When you turn the saw on, press the wood slowly into the blade. Anytime you're taking a curve, you should also do that quite slowly and take it one section at a time. You can always go back an revise a curve. Do not over stress the blade or try to make an acute angle. Discuss the cut with the monitor or technician as a jig saw might also need to be used.

Using a band saw to cut curves in masonite.

The **drill press** is really good if you need to make a lot of holes, or if you need holes that need to be exactly parallel to one another in different materials. It works the same as the one in the metal shop: there is a lever to adjust the height of the table, there is a chuck, which you need to open in order to put the drill bits in. And there is a hand wheel that will draw the drill bit downwards and return it upwards. The key to the drill press, is that you do not try to adjust the table without having loosened the lock on the table adjustment crank, if you do so, you will strip the column, and we will no longer be able to adjust it.



Glue, Screws, Nails, Bolts, & Alternative Fasteners

During the fabrication process, you may want to use additional materials and fasteners to stick things together. The first material is wood glue. I suggest using a small piece of cardboard or an old membership card that you don't need anymore to create a very thin skim coat of glue across the entire surface of what you're trying to join. You don't want air pockets and you don't want excess glue. Then you should clamp at three or more points depending on the size. You will probably need to clamp it for at least 20 minutes before you move on to the next one. You could, however, glue up a few pieces, place them together and clamp them all at once.

We have both wood and drywall screws here in the shop. If you're connecting pieces, and you would like the screws to be invisible, I suggest using a counter-sinking bit. After you drill your pilot hole for the screw, take the countersinking bit and drill the area around the pilot hole. Now, the head of the screw will actually sit below the surface of the wood. This means that you could coat that area with wood filler and sand it down so that the connection point will be almost invisible.

Bolts are usually a way of fastening things that are visible. You would drill all the way through the elements that you're bolting together, and then you would thread the bolts into the end of the nut through those holes and then fasten everything tight. You can also countersink the both sides of that connection point using a paddle bit slightly larger than the hardware so that everything is inset in the wood.

Alternative fasteners could be anything from chain, to fabric, to rope, to zip ties, to wire. I would imagine that most of these fasteners would use some form of a wrapping, or stitching method to combine elements. In that case, you might want to use the drill press to create a series of holes that you could then thread these fasteners through on each of the pieces and then bring them together in order to finalize the connection.

Finishing Mixed-media Sculptures

If you're working with wood, sanding it down is going to be very different than if you leave it raw. Oils, sealers or stains will enhance the surface grain of the wood without masking it completely. You could also use ink washes, or a very light paint wash to get a kind of similar effect. Spray paint is a possibility, as long as you purchase a full chemical respirator (around $45 at most hardware stores and online) and use the spray booths. You could also create a vinyl stencil and then spray paint on top of that to build up a pattern or compliment the texture of your piece. Multi-part resin products can also be used in the spray booth with a respirator if you are interested in a very reflective shiny surface.

Project 3

Due on November 30th, 2021

WEEK 11
TUESDAY October 26
Intro to Project 3
THURSDAY October 28
DEMO: 3D scanning
DEMO: Basic Meshmixer/ Slicer

WEEK 12
TUESDAY November 2
DEMO: Next steps with Illustrator and RD works
DEMO: Wood working tools
THURSDAY November 4
File troubleshooting

WEEK 13
TUESDAY November 9
DEMO: Using the Laser cutter
THURSDAY November 11
Laser cutting day

WEEK 14
TUESDAY November 16
Laser cutting day
THURSDAY November 18
Laser cutting day

WEEK 15
TUESDAY November 23
Open work-day
THURSDAY November 25
Thanksgiving break - no class

WEEK 16
TUESDAY November 30
Critique for Project 3

Assignment:
Create a self-portrait using both digital fabrication processes and hand-powered tools which captures a specific aspect of humor or whimsy related to your personality. Think about changes in scale, material, color, surface, balance etc. Use the digital to push the familiar into the surreal. Be playful.

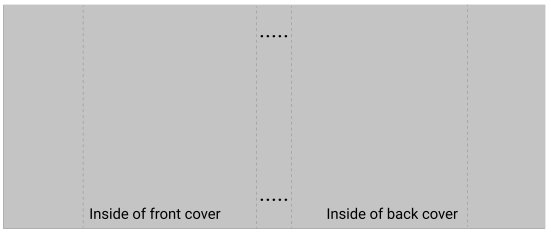
From 3D scans you will be able to create a stack, waffle or folded mesh file that you then export as a set of line drawings which can be cut on the laster-cutter or cut by hand with a jig and band saw if you wish to exceed 1/4in material thickness. You can also choose to make 3D prints of your manipulated files which could be refined and/or used to make a 2-part plaster mold for wax, paper, or slip-casting.
Remember that the materials you choose to combine will have their own cultural/historical and possibly personal meanings behind them and your goal for this project is to communicate a nuanced aspect of yourself through this sculpture. To aid in your process of self-reflection you will also prepare an artist statement to accompany the piece.

Considerations:
A self portrait can seek to present the self by using the body of the artist as a model, or it can be the self as expressed through a more abstract means: literally an abstraction of the body, or the use of symbols and objects as stand-ins for some component of the personality of the creator.

Objectives
Use 3D scanner to capture your body and/or personal objects • Learn the basic use of Meshmixer, Slicer, Illustrator and RD Works • Combine various media in a final sculpture

Artists:
David Atlmejd, Guido Maestri, Jedediah Morfit, Kiki Smith, Oliver Laric

How to Fold and Stitch a Sketchbook



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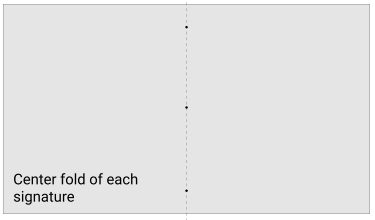
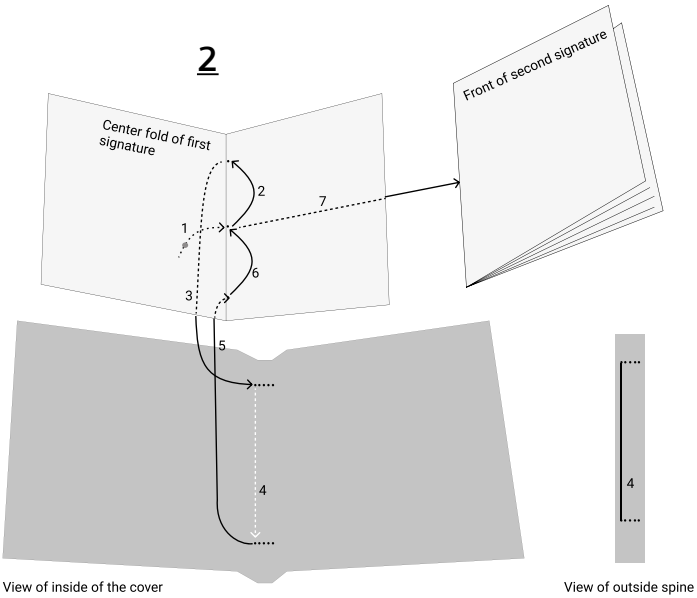


The first step in making a sketchbook from scratch is measuring out and cutting the materials. For a soft cover book you will need a card-stock that is sturdy and flexible, and then various papers to make up the insides of the book. Each group of pages folded in half is called a signature. We will be stitching each signature into the cover at the center-point called the spine. It is nice for the cover to be just slightly larger than the pages.

Once you have each of your signatures and the cover ready, you should pre-punch the holes before you sew. With a scrap paper measure a center line and then a point about 1.5 inches from the top and bottom of the page height. Use this as a guide to mark those three points on the outside spine of each of your signatures. Also transfer over the top and bottom points, one for each signature, onto the spine of the cover. Punch with your needle or an awl.

With a length of waxed thread about 60 inches long, thread your needle and tie a knot on the tail end, do not double over the thread. Following the diagram to the right, start with your first signature (the one farthest to the left) and pierce the center hole from behind. Next, draw through the top hole on both the signature and the cover. Take the needle along the outside spine all the way down to the bottom hole and go through both it and the bottom hole of the signature. In the next move, take the needle back through the center hole and come out on the other side (between the signature and the inside of the cover) tightening everything as much as possible. Finally, make a double knot with the tail of your string and repeat the whole process by coming up into the middle hole of the next signature.

2



View of inside of the cover

View of outside spine

When you finish stitching in the first signature, tighten everything except the tail end with the knot — leave that about 5in so that you can use it to tie off the final signature at the end.

3