WOODSHOP ORIENTATION

HARVARD GRADUATE SCHOOL OF DESIGN

This PDF is meant to accompany the in person woodshop orientation given at the beginning of the Fall semester. The text is written in the style of the spoken presentation and is intended to be used as a refresher for that information. Specific questions about machines, protocols, or processes should be directed to Fabrication Lab staff or TA's.

INTRODUCTION

Welcome to the Harvard GSD's Fabrication Lab Woodshop Orientation. We will spend the next hour and a half in the woodshop introducing the space, identifying shop protocols, and demonstrating proper use of the available tools and resources.

Everything I will be presenting today is also available online. For many of you, I expect that much of this orientation is new information and this is not your only opportunity to access it. There is a PDF document available on the woodshop page of the GSD website that presents this same information with text and pictures. I am following that script and, if you do choose to review the document, it should be very familiar having previously been presented the same information.

Attending this orientation, coupled with the completion of 3 online trainings, will grant you access to the Fabrication Lab by using the card swipes on the main doors. All of the Fabrication Lab spaces are accessible by your Harvard ID card. Before attending this orientation you should have already completed 2 of the online trainings- **the standard Fabrication Lab agreement** and the **Hazardous material training**. Once we have completed this orientation, you will need to back online and complete a short review and quiz of the material presented here today. I urge you to do this as a soon as possible, while what we have discussed is fresh in your mind.
The greater Fabrication Lab is located primarily in the basement of Gund Hall and encompasses many different departments. The woodshop, where we are now, is one of those fabrication departments and others are located on either side of us along the basement hallway. **Other FAB LAB departments include:**

CHRIS, RACHEL, + BURTON

- Laser cutting
- 3D printing/scanning
- the Zund machine
- CNC machines
- both precision and rough metalworking
- Robotics

Also located along the main hall in the basement are a 24 hour work space we call the project room, administrative offices, and the school material store.

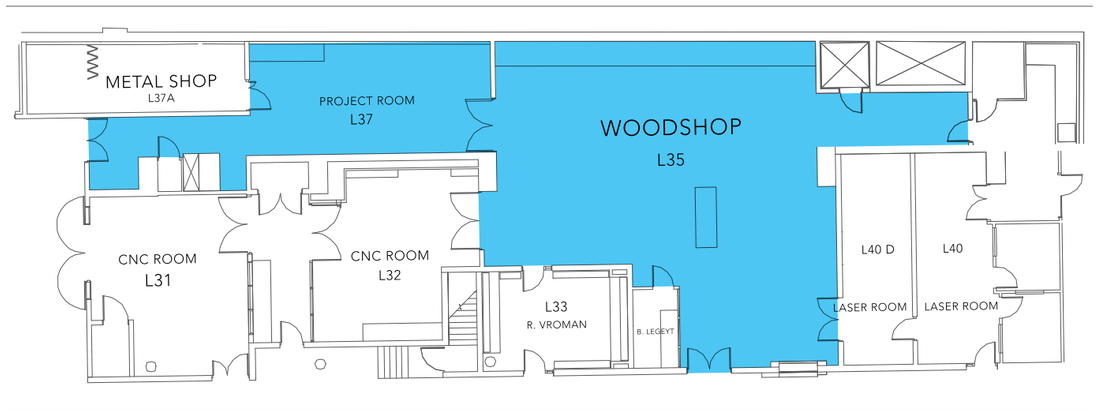
3 staff members manage the entire lab and hire and train over 90 student workers to help keep everything running smoothly. I am one of those staff members– my name is Burton LeGeyt and my office is here, in the woodshop. The other staff members are Rachel Vroman and Chris Hansen. Each of us can answer general questions about any part of the Fabrication Lab but we have specific areas of expertise and individually manage distinct groups of student workers in the departments we oversee. If you have a specific woodworking or metalworking question you would likely direct that to me. Chris could best answer technical questions about our laser cutters and 3D printers and Rachel can best help you with inquiries regarding digital fabrication as it relates to CAM operations for the CNC machines and robots.

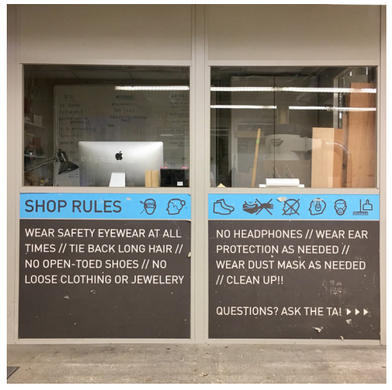
The 3 of us cannot manage everything that goes on within the Lab by ourselves and we rely heavily on student workers to manage day to day operations. As you make use of the Fabrication Lab you will engage with your fellow students as they monitor, manage, and operate the resources available to the student body. As you can imagine, students come to the GSD with varying degrees of technical experience. A familiarity with the resources is one important aspect of our hiring process but you should not assume that the student worker you are engaging with is an expert in their field. Everyone is in some stage of training, even the most senior TA's.

When dealing with fabrication procedures, there is rarely only one way to complete the process. Depending on the desired outcome, the materials used, and the skill of the person requesting advice, the recommendations you receive may vary. You may ask the same question of multiple TA's and get different answers; this isn't necessarily a bad thing. With issues of safety, you should feel confident that the students monitoring the spaces will give consistent answers. For the best way to accomplish a fabrication task, though, there will almost always be multiple options. You are welcome to check with the appropriate staff member if you would like a more experienced opinion.

The TA's for the woodshop are located at the TA desk, in front of my office. When on duty, they are in charge of the space and your questions should be directed to them. On the rare occasion that there is no student worker on duty I will be managing the shop. The woodshop is never available for use without a trained monitor on duty.

It is important to make clear that we assume most of the student body is unfamiliar with the tools and procedures common to a working woodshop. As such, we expect users of this space to have questions- The TA's are here to make sure you are working safely but also to assist you in realizing your fabrication project and you should feel comfortable asking for assistance, we expect it. Even if you find yourself asking the same, or similar, questions repeatedly, it is not a problem. Until you are





TA DESK + SHOP RULES

extremely confident in your process, it is necessary to ask for input from the staff and shop TA's.

The hours and TA schedules for the Woodshop are posted on the door and available online. We have traditionally been open from 10-10 M-TH, 10-6 F and 12-8 each weekend day. The project room, which is adjacent to the woodshop, is open 24 hours and accessible from the back hallway as well as the woodshop, when it is open.

While working in the Fabrication Lab you must observe proper attire and safety etiquette. In the woodshop, these rules are strictly enforced. Restrictions on clothing are as follows:

Footwear must cover the entire foot, be secure on all sides, and provide a stable working posture. Shoes such as sandals, clogs, ballerina flats, and heels are prohibited. You must have proper footwear on to enter the woodshop.

All loose clothing must either be removed or completely tied back. Things like scarves, loose sleeves, ties, and drawstrings are a very real hazard when working with machinery with moving parts. Long hair (including long beards) must also be tied up in a way where it cannot come loose. We do supply hair ties for this purpose. There have been fatal accidents at similar educational shops from a student's hair getting caught in a machine. We take this very seriously– staff and TA's are constantly watching and will alert you if we see you about to put yourself in a dangerous situation. I would ask you to also be aware of these safety issues and do a thorough self-inspection before beginning any work in the woodshop.

All loose jewelry and all rings and bracelets should be removed upon entering the shop as well. Your arms and hands should be free from anything that could get caught in a moving machine part. Gloves can be worn when handling either very rough or hot material but absolutely must be removed if you begin using a machine with moving parts. Lastly, headphones (that play music, wired or wireless) and ear buds of any kind cannot be worn when in the shop.

I will give examples as we move around the shop of possible injuries that may occur when using specific machines. I realize that some of these may seem graphic, butI am not sharing them to scare you. Rather, safe use of the resources in a shop like this requires knowing the specific risks present, and understanding the common injuries that may occur is important when using a tool safely. While this is a space with potentially dangerous tools, I do not consider it an inherently dangerous place.

Your safety is our first priority and the tools and protocols of the shop are set up in a way that reflects that. We will help you be productive, and to complete your work, but never at the expense of working safely.

Other general safety etiquette:
- You should not be working if you are tired, very stressed, or otherwise impaired.
- You must never work alone.
- Never leave a machine while it is running for any reason.
- Never interrupt, distract, or walk directly behind someone operating a machine
- Never place your hands in a dangerous position in relation to a moving part of a machine
- and lastly, please notice how clean and orderly the woodshop appears.

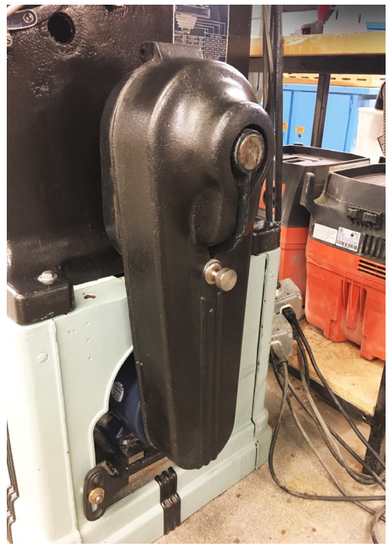
We take pride in keeping it this way and we rely on your assistance to maintain this level of cleanliness throughout the semester. The TA's do a tremendous amount of work behind the scenes opening up every machine and performing weekly preventative maintenance, restocking consumables, and keeping all the small details necessary to a fully functioning shop stocked and well-tuned. We expect you to keep your immediate workspace clean and clear of unnecessary debris and to fully clean both the space and tools that you utilize when in the shop.

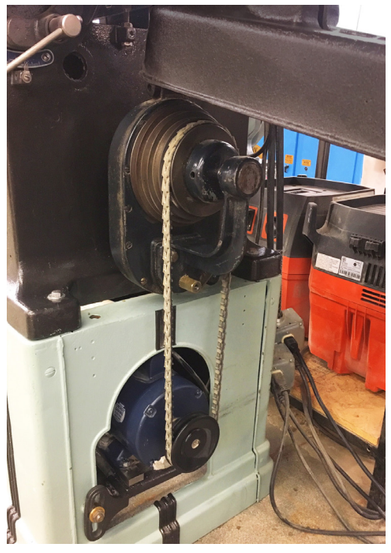
In that spirit, please make use of our shop vacuums and discard material in its appropriate receptacles. We have two different styles of trash bin– a standard grey style for trash and red barrels for wood recycling.

Any solid wood, clean plywood, or OSB can go in the red bins to be recycled. If it has paint or any metal fasteners, it will need to be discarded in the regular trash. Wood is the only thing we recycle; any other items that can be recycled should be taken upstairs to the Chauhaus where they have other recycling stations.

PPE stands for personal protection equipment and we supply many different types in the woodshop. They are located in the wide drawers in front of the TA desk. Safety glasses are required PPE while in the woodshop. Regular glasses do not count as safety glasses as they do not wrap around the sides of your eyes and you will need to wear a pair of safety glasses over your regular glasses while in the woodshop. We supply both headphone style ear protection and small expandable foam style ear protection for use in the shop. It is not required that you wear these for any specific machine or procedure but

PPE DRAWERS + TRASH CANS





MOTOR GUARDING

they are here for your convenience if you choose to.

In the bottom drawer we have gloves and dust masks. We supply both heavy work gloves and nitrile gloves. The work gloves should be used and returned while the nitrile gloves are single use and should be discarded after being used. You do not need to use the nitrile gloves only in the woodshop/Fabrication Lab- you are welcome to take them for use offsite. They are here for you to utilize when you need them and we will always replenish our stock.

The dust masks we supply are the small cotton masks that are held to your face with an elastic band. These supply some protection, especially from larger particles, but do not supply complete protection. There is no machine or process in the woodshop where you are required to wear these dust masks. Even while sanding, there is dust collection in place that removes the dust at the source.

Having introduced proper woodshop etiquette and protocols we can begin to look at the individual machines you will have access to upon entering the woodshop. We will discuss the standard operating procedures for these machines and I will demonstrate their safe and proper use. You may notice that we do not interact with every machine in the space- some machines are restricted from general use and you will need to work directly with a TA or staff member to utilize them. These include the jointer/planer, widebelt sander, and routers.

As mentioned earlier, if you have little or no experience using these machines you should ask the shop monitors for assistance. Until you are fully confident in what you are doing it is necessary to have a trained shop monitor observe you while working with power tools.

POWER TOOL OVERVIEW

Before we begin looking at the table saw lets address some general considerations about working with power tools. When you turn on a power tool you are, quite simply, powering on an electric motor. You rarely see that motor, it is almost always safely hidden inside the body of the tool. This keeps you protected from the pulleys and gears that put the moving parts in motion. That motor may be fast or slow, quiet or loud. It may be powering any number of cutting, sanding, or grinding attachments. In every case, though, it is important to appreciate that the electric motor you have activated is more powerful than you are. In a hypothetical test of strength between you and an electric motor on a power tool you will never win. Sometimes it may seem like you can slow down a motor when using a power tool but that is always due to some extreme mechanical advantage inherent in the tool. The motor, by itself, is extremely powerful. This is important to keep in mind and understanding this is necessary to using power tools safely. When you turn on that tool you are unleashing a power greater than yourself and you are responsible for that power until you turn it off and it comes to a complete stop.

There are two words, or attitudes, that should define your process when working with power tools. You should be very **DELIBERATE** and the work should be very **PREDICTABLE**. Any time you are using a power tool you should be working with these words in mind.

The GSD is a dynamic and creative environment. Many of you came here specifically to experience this creative culture, and that is understood and fully supported by the Fabrication Lab. I would ask you, though, not to extend the culture of loose experimentation to your work with power tools in the woodshop. When we are working with these tools we must always know exactly what we are doing and the expected result of our interaction with the tool. There is never any guessing about what might happen. That isn't to say we can never use them in a new and novel way, that is possible. Before we do that, though, we will examine the entire process and come to a firm understanding of what the end result of that new method will be. Only then, once we are sure of the outcome and that the process is safe, will we begin our interaction with the tool.

As we look at specific power tools in the shop we will be focusing on the force that the blade/belt/cutting tool will exert on our material. Understanding this is a necessary step to using the tool safely.

The first three tools we look at will all use the same blade, a circular saw blade. A circular saw blade is a large flat steel disc with a central hole, through which it is mounted securely to a rotating spindle. There are teeth cut around the perimeter of the blade and, if we look closely at those teeth, we can see that they are sharpened on the front facing edge only. They may feel slightly sharp on the sides, but the teeth are not sharpened in a way that would allow for accurate cutting on the sides. Knowing this, we can understand that the blade will only work as designed if it moves through the material (or the material moves through it) perfectly in plane with its rotation. The blade cuts at its leading edge and creates an opening, or kerf, that allows for the rest of blade to pass though as the cut continues.

CIRCULAR SAW BLADE

Anything that contacts the sides of the blade will either contact with the teeth in a way that they aren't designed to cut or contact the solid body of the blade. This can create heat, friction, and a jagged edge- all things that could be detrimental to our material and/or dangerous to us. When used correctly, though, a circular saw blade is capable of giving us an extremely

DELIBERATE & PREDICTABLE

WHEN USING POWER TOOLS

clean and straight edge. We can create edges that require no further cleanup– edges that could immediately either be glued into a larger system or put into immediate use. In the woodshop, we rely heavily on the precision that a circular saw blade allows us. Let's examine some of the tools that utilize this blade.

TABLE SAW

Looking at the table saw we can see the circular saw protruding from the top of the saw. The blade is mounted securely to the spindle and will begin to spin when the tool is turned on. Let's power it on and see how smoothly the blade spins when in motion. Remember, the circular saw blade can only work as designed when it is used in plane with its rotation. That assumes, of course, that it is mounted correctly and able to spin without any deviation, or wobble. As we will see, the table saw allows for this extremely precise rotation.

You will notice that when I power on the table saw the dust collector also powers on. Most of the tools in the woodshop are connected to automatic dust collection and this greatly reduces the visible dust in the shop. The dust collector pulls the dust into the body of the saw and then, through pipe and hoses, into the body of the dust collector. It will remain on for 10 seconds or so after the table saw has been turned off to completely clear those lines.

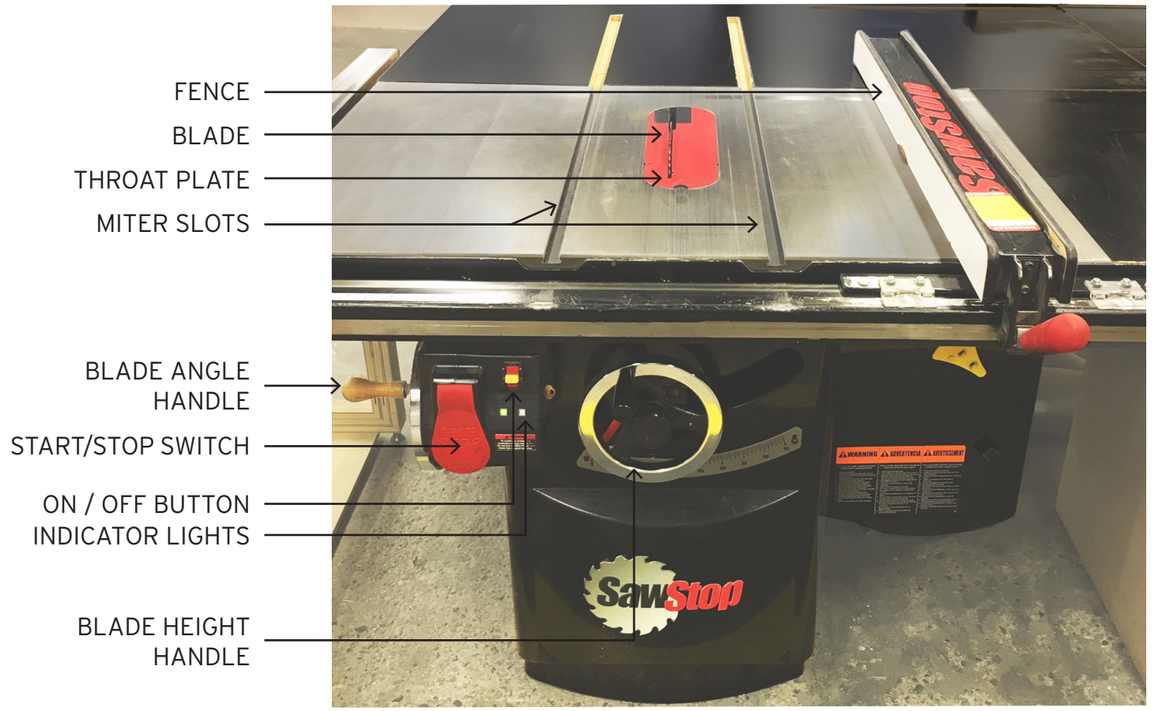
TABLE SAW POWER PANEL

To power on the table saw I will use the control box on the front of the tool. The yellow switch needs to be in the up position; this will activate the red and green lights and they will begin blinking for a few seconds. The saw can only be powered on when the green light is illuminated by itself. Once it is, the large red paddle switch on the left will activate the saw. Pull the paddle out to turn it on and push it in to stop it. On occasion, the green light will remain blinking or the red and green lights will both blink. If this is the case, ask the TA for assistance.

Looking at the blade mounted in the saw, and especially once seeing it run, I can immediately identify two serious safety concerns. The first is the possibility that part of your body may come into contact with the blade while using the saw. This isn't purely hypothetical; table saw accidents are incredibly common and happen every day. These accidents can range from a slight abrasion to the loss of fingers and, in the most serious cases, the death of the operator. The style of saw we have here in our shop is a Sawstop brand table saw and it has a safety mechanism built in that reduces the likelihood of a serious accident through contact with the blade to almost zero. The Saw can sense when our hand is touching the blade and will immediately stop the blade and remove it from the working surface of the tool.

If you look inside the saw you can see an aluminum cartridge mounted directly under/behind the blade. That aluminum cartridge is wired directly into the tablesaw and ready, through the use of a powerful spring, to embed itself into the blade and act as an extreme brake, stopping the blade instantly. Another pin releases at the same time and will force the blade to drop into the body of the saw. We experience this event as a dull thud sound and the blade disappearing immediately from the surface of the saw. It works wonderfully and consistently- the owner of the company is rumored to demonstrate its effectiveness with his own hand.

How does it work? It senses contact with our bodies through a slight electrical signal in the blade. If we touch the spinning blade, we complete a circuit that immediately releases the spring and the cartridge. The process utilizes our bodies' inherent conductivity. As you may imagine, other conductive



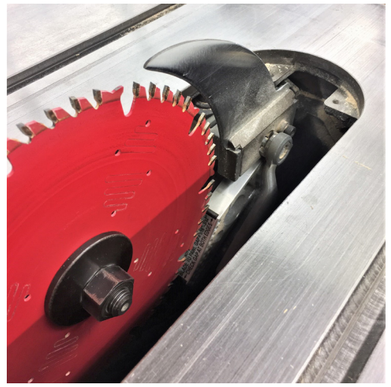


TABLE SAW BLADE + CARTRIDGE

materials will also cause the mechanism to trigger. Aluminum is something that can normally be cut cleanly (although with care) on a table saw but we cannot do so on this saw. Wood that is extremely wet can be conductive enough to set it off; if your wood has not been dried properly it will need to be cut a different way. Plexiglass will cut without issue but the coating on mirrored plexi contains enough metal to trigger the sawstop.

There are material limitations because of this safety mechanism but, considering the benefit of it, we gladly accept them.

It is important to mention that proper use of the table saw will always result in our hands being a safe distance away from the blade. Under no circumstances should we take this safety mechanism for granted and use the saw in a way that creates unnecessary risk. At some point, if we engage regularly with any sort of woodworking, you will likely work with a table saw that does not have this safety mechanism in place, most table saws do not. I would hate for you to learn a bad habit here that then makes any subsequent use inherently more dangerous.

The second safety consideration that I recognize from viewing the spinning blade is the possibility of the blade catching and making a projectile out of the material being fed into it. Like our previous example, this is not a rare occurrence; it happens regularly.

It is referred to as kickback and can be extremely dangerous– while a cutting injury may be a more visceral image, the danger from projectiles being thrown out of the saw can be just as severe. Kickback is a result of the operator not controlling the material properly. The material gets caught up in the rotating blade and, based on the direction of force inherent in the spinning blade, is directed violently back towards the user. Limiting the possibility of a kickback event is as simple as maintaining firm control of your material as you are cutting. Firm control will always utilize rigid accessories of the table saw; pure "freehand" cutting on this tool is not safe and never allowed. We will discuss exactly what this entails when introducing the proper procedure and accessories for both rip and cross cuts.

Before we do, though, let's look at some basic attributes of the table saw. We have viewed the blade without the throat plate in place but we would never use the saw without it installed. It rests in place surrounding the blade and extends the table top right to the edge of the blade limiting the possibility of any part of our stock falling into the body of the saw. When you approach the table saw, the throat plate will be installed. Visible directly behind the blade is a curved metal fin called the riving knife. It must always be in place when using the standard blade on the table saw. It may look simple but it is an extremely important safety mechanism and helps to limit kickback when using the saw. We will discuss its benefits more when we discus cutting unstable materials.

On the body of the saw are two large handwheels. The one in front will raise and lower the blade; this is something you, as the operator, will do regularly as your stock size changes. The handwheel on the lefthand side of the saw will angle the blade from its set position at 90 degrees to the table top, to an angle of 45 degrees tilted to the left (always away from the fence). If you need to angle the blade, ask the TA on duty for assistance. The angle gauge on the front of the saw is not precise and the TA has undergone training to identify exactly what angle the blade is set to.

It is a common occurrence, when using power tools, that the setup time for a specific operation can take many times longer than the time needed to make the cut. This may seem burdensome but it is a productive use of your time. Making a cut quickly that then requires touching up by hand will take longer overall and generally leave you with a surface both less accurate and less smooth. The time spent setting up a cut that leaves an extremely precise result off of the saw is a good use of your shop time.

Safe use of the table saw begins with careful material selection. We have a simple guideline for what can be cut on the table saw- material must have a flat face and at least one straight edge. This applies to all tools that utilize the circular saw blade but we are very strict about these attributes when cutting on the table saw. The flat face and straight edge are necessary because we need to exert extreme control over our stock any time is in contact with the blade. Both the flat face and straight edge will be held firmly against rigid parts of the table saw while the material is being cut.

We also want to be sure that we are always supporting the longest edge of our material material with a rigid part/accessory of the table saw. This will usually dictate whether we are making a rip cut or a cross cut– whether we are working along the longest edge or across it. Again, this is a crucial aspect of safe use when working with the table saw.

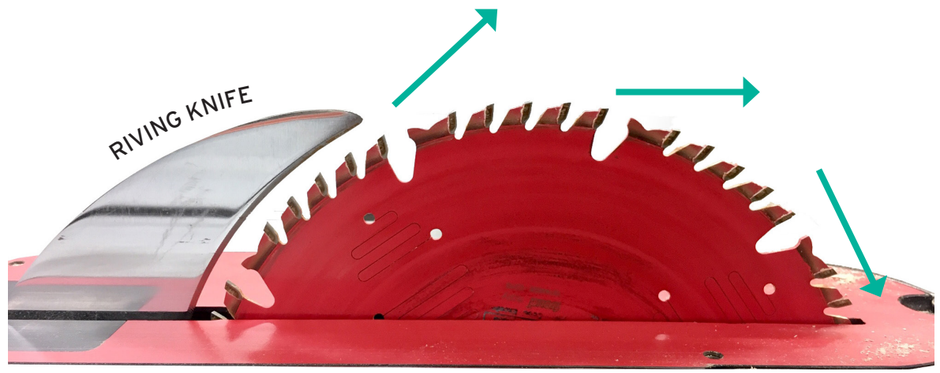


TABLE SAW DIRECTIONAL FORCE

FLAT FACE

LONGEST EDGE

STRAIGHT EDGE

As mentioned, there are two basic types of cuts on the table saw. A rip cut and a cross cut. Let's begin with a rip cut.

When performing a rip cut we are creating a long straight edge parallel to the longest straight edge of our material. This edge can be as precise as we can measure- one of the biggest benefits of the table saw is the ability to make extremely precise and clean cuts.

For a standard rip cut, the large flat face of our material will be held down against the table top of the saw and the straight edge of the material we would like to reference is pressed firmly against (and slides along) the table saw fence. The fence slides side to side along the steel bar mounted to the front of the table saw and can be locked in place by pressing down on the red handle. With the help of a measuring device (ruler, tape measure), you lock the fence in place to be a specific distance away from the inner face of the blade. When locked in place, the face of the fence will be in plane with the table saw blade, as it must be to use the tool effectively.

The steps I would take in preparing to make a rip cut are as follows:

- Place the material next to the blade and either raise or lower the blade until you can see approximately 1 tooth gullet (the small cutout in front of the blade tooth) visible above the stock.
- Set the fence to be the correct distance away from the blade and firmly lock it in place.
- Position yourself to the left of the fence and in an ideal spot to exert force against the fence with your stock. If the distance between the fence and blade is less than 8 inches make sure you have a push stick ready and in a place where you can access it when necessary.
- Make sure there is no one standing directly behind you, that space should be clear of people when the table saw is in operation

Your priorities when making a rip cut are to keep the material firmly in contact with the fence and table while also pushing it through the blade. The face of the fence is perfectly in plane with the blade; TA's check and verify this each week during their preventative maintenance of the tool. We know that to use a tool that utilizes a circular saw blade to its advantage we need to work in plane with the blade; the fence allows you to do that.

Any deviation from the face of the fence will cause the material to contact the blade on the side and against the teeth where they are not designed to cut. This will cause friction, a degrade in the cut edge, and lead to the possibility of a dangerous kickback event. If you maintain firm control of your material when this slight deviation occurs, you can respond and correct it without great risk. If you lose control, however, you put yourself in danger. **You absolutely must maintain control of the material anytime it is in contact with both the blade and the fence.**

If kickback is going to occur, it is almost certainly going to be the stock lodged between the blade and the fence that will build up enough force to be thrown out of the saw. That the material is positioned in that tight space, with nowhere else to go, exacerbates the possibility. That is why it is so important that you are in control of the material between the blade and the fence when making a rip cut on the table saw. The size of that material (and it may be either larger or smaller than the offcut) doesn't matter. Always push it through the blade until it is completely clear of contact before letting go.

We are not as concerned with the material on the other (non-fence side) of the blade. It may also be in contact with the blade but is not wedged into a tight space in the same way as the material between the blade and the fence. If it does come in contact with the blade, it is likely to move away from the blade and will then no longer be in contact. The potential energy is dissipated and the likelihood of it being thrown from the tool is diminished.

Sometimes the fence is extremely close to the blade and it is not safe to use your hand to push the material through end of the cut. Anytime that space is less than 8 inches you should use a push stick to complete the cut.

When using the table saw you will need to push the material through the blade with some force as the cutting action of the blade is pushing back against you. Sometimes, in the process of making your rip cut, that force will increase. This is not uncommon, and not necessarily a cause for immediate concern. If the force increases to a point that you become uncomfortable, though, you may need to react.

The correct way to interrupt a cutting operation is to lock the material in place by exerting extra force both down against the table top and against the fence while using your leg to turn off the table saw. The large red paddle switch that powers the table saw is designed to be extremely sensitive and is positioned at a standard leg height when using the saw correctly.

PROPER TABLE SAW OPERATION

“Maintain control of the material between the fence and the blade at all times”

Lock the material in place and use your thigh to turn off the saw. Once the blade has stopped, you can remove the material and identify why the force was increasing. Two things you should NOT attempt are to back the material out of the cut or pick up your material from the cut while the blade is spinning. Either of these things will put you in danger.

The most likely reason for increased force directed back at you is the material warping while being cut. As it warps, it exerts pressure against the side of the blade and that friction is the force you feel directed back towards you as you are cutting. It is also the exact condition necessary to produce a kickback event. Your control over the material is the only thing stopping that from happening.

Manufactured sheet stock (plywood, MDF) is engineered to remain stable; it is unlikely that it will warp while being cut. Solid wood, though, is likely to warp or distort, when cut. Every stage of the processing of solid wood can affect its stability. How it grew, how it was milled, how it was both dried and stored– the specific methods applied in each of these processes can either increase or decrease stability in the material. It should be assumed that solid wood will move slightly when cut and you should plan ahead for this possibility.

The riving knife, the small curved metal piece behind the blade, is in place to keep the kerf we create when cutting open, especially so when the material wants to warp and close up on the blade.

LONGEST EDGE IS NOT SUPPORTED

The rip cutting of plywood and other engineered material is usually completed without incident and, assuming proper procedure, our stock should have a beautiful clean cut edge that shows excellent definition and crispness on its face and edges. When we measure the width along its length, it should correspond perfectly to the measurement we made between the fence and blade when we set the fence. Any deviation from that measurement, or in width along the edge, will be from user error in making the cut. The tool, when used correctly, is absolutely capable of extreme precision.

Let’s assume that our goal in using the table saw was to make a set of perfect squares. We have a long length of stock and we would now like to cut it across its length to make these squares. The fence is still set to the width of the stock and it may seem like a good idea to simply re-orient the material and continue to use table saw in its current setup to cut the squares.

It should be obvious that this is ill advised. As we discussed before, using the saw safely requires us to always support the **longest edge** of our stock and when using the fence to make this type of cut we are using the short edge to control the stock. This is dangerous and we will need to modify how we set up the table saw to make this cut safely.

This type of cut, where we are cutting across the longest length, is called a **cross cut**. For a rip cut we utilize the fence to control our material. For a cross cut, though, the fence cannot help us control our longest edge and we need to move it out of the way. Instead of the fence, we will utilize tooling that fits into the two slots that flank the blade on the table saw top. These slots are called the miter slots and they, like the fence, are perfectly parallel to the plane of the spinning blade. There are many accessories that fit into these slots and allow precise motion that is perfectly perpendicular to the blade.

We will use a large MDF sled to make our cross cuts in the stock we have already ripped to width. The sled has metal guides on the bottom that correspond to the miter slots; it should easily fit onto the table top and move back and forth. There is a slot in the middle of the sled to allow access to the blade and a rigid rear edge that the longest edge of our stock will bear against as we slide the sled forward and backward. Place the stock on the sled with pressure against that back edge. There are many ways to set guides to dictate the exact length being cut; TA’s have had training in these methods and can assist you in determining which is best for your intended cut. With the longest edge held firmly against the thick back rail, slowly slide the sled through the blade. Continue through the blade until your cut is complete and then slide it back towards yourself. Re-orient the next cut and repeat.

The table saw is a tool that the shop TA’s watch closely, and with good reason. The risk associated with using the table saw is high, and the material that you may choose to cut can compound that risk if it is either poorly chosen or not prepared correctly. Please take advantage of the TA’s and staff when using the table saw. Ask for help, request a refresher, get confirmation from a trained user on your intended process. Our goal is for you to acquire skill and confidence, and to make productive and safe use of the table saw. Most students who come to the GSD will need assistance to reach that level of use.

We are here to help you reach that level; please use us as a resource.

PANEL SAW

The table saw is a wonderful tool but when the material we would like to cut is extremely large it can be difficult to maintain the level of control necessary to use it to its advantage. When purchasing material it is cost effective to purchase full sheets; most sheet material here will come in a 4’ x 8’ size. Depending on the material and thickness, that large sheet can weigh 50 pounds or more. Even if you are accustomed to working with large sized material, it can still be difficult to control it as carefully as

CIRCULAR SAW V. PANEL SAW CHASSIS

you would like on the table saw.

The panel saw solves that problem by allowing us to move the blade through our material instead of moving our material through the blade. This allows us to position our heavy and cumbersome sheet in a fixed place and let the blade do all the work. Let's examine how it works.

To introduce the panel saw lets first look at a common construction tool, a circular saw. This is a handheld tool that utilizes a circular saw blade, just as the table saw and panel saw do. The saw is held from above and manually pushed through stock that is (usually) laying flat. Looking at the circular saw upside down, we can see that it resembles a very small table saw. Using the circular saw manually takes skill, and practice. With that practice, it is certainly possible to make extremely straight and clean cuts. It is not easy, though.

The panel saw uses the body of the circular saw but positions it on a fixed chassis that moves in a single plane. We discussed how important this is to using a circular saw blade to its advantage; The blade must move through the material in plane with its rotation to give us our perfectly clean cut edge. The panel saw is designed to work in this manner.

Looking at the panel saw we see a circular saw body mounted on the metal chassis. That chassis rides on two vertical metal rails that allow for its movement both up and down. The on/off switch is a red paddle switch that is activated when pulled up/out. The saw will remain on until the switch is pushed back in; you do not need to maintain contact with the switch to use the tool. On the front of the saw, the dust collection hose is pressed into a flange on the blade cover. You may, when making accurate measurements, pull the dust collection hose out to best view the exact cutting point.

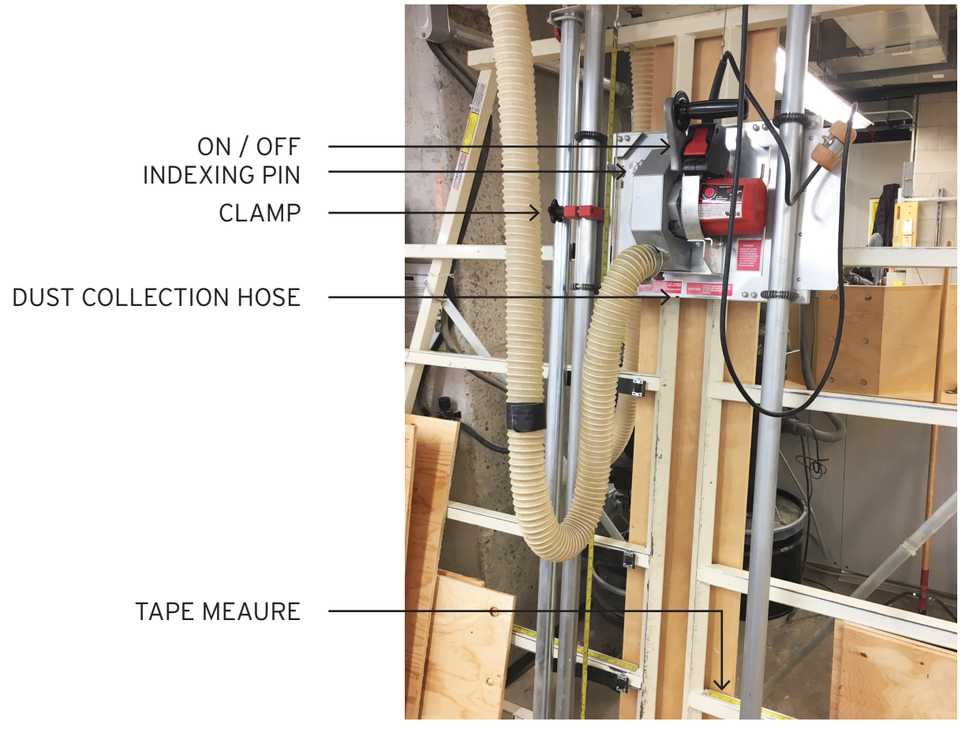
Material is loaded into the panel saw from the left. As we have discussed, material cut on a tool that uses a circular saw blade needs to have a flat face and a straight edge, this is no exception. The flat face will bear against the steel rails of the tool frame and the straight edge will rest/slide on the red rollers at the base of the tool. Your material will be fed into the machine along those red rollers and through the black metal friction clamps mounted to the lefthand round rail. These keep pressure on the stock and help keep it stationary when cutting.

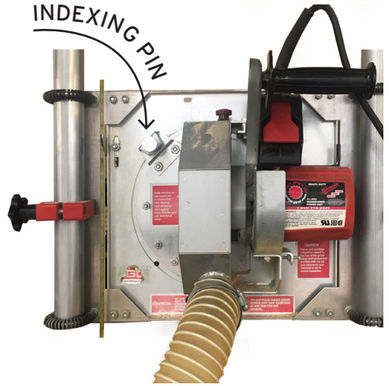
Measurements can be made with the supplied ruler mounted along one of the steel rails of the tool frame. For the most precise cut, though, make a pencil mark at the top of your stock and view it through the dust collection tube on the body of the saw (remove the hose to view). Lower the blade down until you can see exactly where it will contact your material and adjust accordingly.

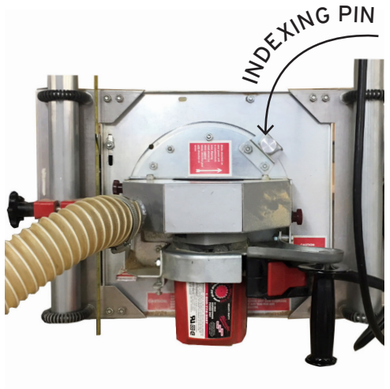
Once the material is in place an your measurements have been made you are ready to make your cut. Power the saw on with the red switch and slowly lower the blade down and into your material. Lower the saw all the way through, turn it off, and then slowly let it retract to its highest position.

This cut is just like the cross cut we made on the table saw, but on a larger scale. We are cutting across the longest edge of the material, and we have supported both the flat face and the straight edge against rigid parts of the tool. Let's imagine, though, that we would like to make a rip cut. If my stock is a full sheet, and is 8 feet long, I cannot simply re-orient it to cut down along that 8 foot length. The saw is not tall enough to allow for that the longest edge would not be supported. Instead, I will need to re-orient the saw blade.

Looking at the saw chassis, there is an aluminum (polished metal) knob to the left of the blade. This is a spring loaded pin– pulling it out will unlock the saw and allow it to be rotated. Spin the saw body clockwise and once it has been rotated 90 degrees the spring loaded pin will lock into the other indexing hole and the saw will be oriented horizontally. With the saw in this orientation you can manually push your material in from the left and through the blade and make rip cuts of whatever size. There is a scale mounted along the lefthand round rail that can be used for measuring. Again, though, your most accurate method will be with a small pencil mark, and to view that mark though the dust collection tube.







SAW BODY ROTATION

The panel saw, being another tool that uses a circular saw blade, makes very similar cuts to the table saw. It does so with less risk, though. Our first serious concern on the table saw involves the possibility of coming into contact with the blade while making a cut. On the panel saw, there is a large guard in place covering the blade completely. It is difficult to even see the teeth of the blade with it in place. The other serious concern with the table saw is a kickback event, or the risk of material being thrown out of the saw. When making a rip style cut on the panel saw the material between the blade and the "fence" (the red rollers on the panel saw) is physically below the blade; the risk of that material moving up and getting pinched into the blade is mitigated almost completely. That, combined with the lower power of the panel saw motor and the larger size of the stock makes the risk of a kickback event almost nonexistant.

Understanding all of that it should become clear that the panel saw will do much of what the table saw can do but with less risk to the user. Why use the table saw at all then?

A helpful way to think about it might be this: For larger stock the panel saw is almost always a better option. For smaller stock, the table saw is preferable as the open spaces in the frame and lower rail of the panel saw are too large to support very small pieces. For material in the grey area in between large and small it will depend on your comfort level, both could do a perfectly adequate job. The table saw will be slightly more precise and cleaner but that isn't always necessary. If you aren't sure which to use the best option is always to consult a shop TA or staff member.

SHOP VACS

Behind the panel saw is where we keep most of our cleaning supplies. Brooms, dust pans etc....we also park our mobile shop vacs here. These are the easiest way to quickly clean up any small mess made while working in the woodshop.

We use cyclonic style shop vacs and they work wonderfully. They are much more powerful than standard shop vacs and will easily pull dust from inside corners and clean off any tool or workbench. Each shop vac should have 2 attachments- an angled wand and a brush attachment. These attachment tips fit on the end of the hose by friction and can be swapped out whenever necessary.

The on/off switch is tricky to find— on the back of the vacuum is a panel with a large hole. Reach inside this hole and the switch is under the back of the vac body. Once plugged in to a standard wall outlet this will power it on and off. There are standard outlets all over the shop, any one of these will work to power the shop vac. When done please recoil the power cord around the aluminum holder and wheel the vac back to its place behind the panel saw.

MITER SAW

The compound miter saw is the last tool we will examine in this orientation that uses a circular saw blade. As is clear by now, that dictates that this tool can only make very clean and straight cuts. Similar to the panel saw, there is an approximation of the handheld circular saw positioned as the main cutting tool of the miter saw. On the panel saw, the circular saw body was fixed to a chassis and limited to one single movement. On the miter saw, the circular saw body can move in two ways— pivoting up and down, and riding in and out along the two linear rails.

With the blade guard retracted, we can see the orientation of the circular saw blade's teeth and understand in which direction it will rotate. In this case, the cutting action is away from us and force is directed back and against the rear rail of the tool. This is where we will lock the straight edge of our stock— as this tool uses the circular saw blade we are still concerned with our material having a flat face and a straight edge. The flat face will be held down against the horizontal surface of the saw frame and the straight edge will be held firmly against the rear rail of the tool while the cut is being made.

The miter saw makes cross cuts only. Both the table saw and panel saw can facilitate cutting along the long edge to make rip cuts but the miter saw is only set up to make repeat and quick cross cuts. There is no way to rotate the head to allow for that longer cut.

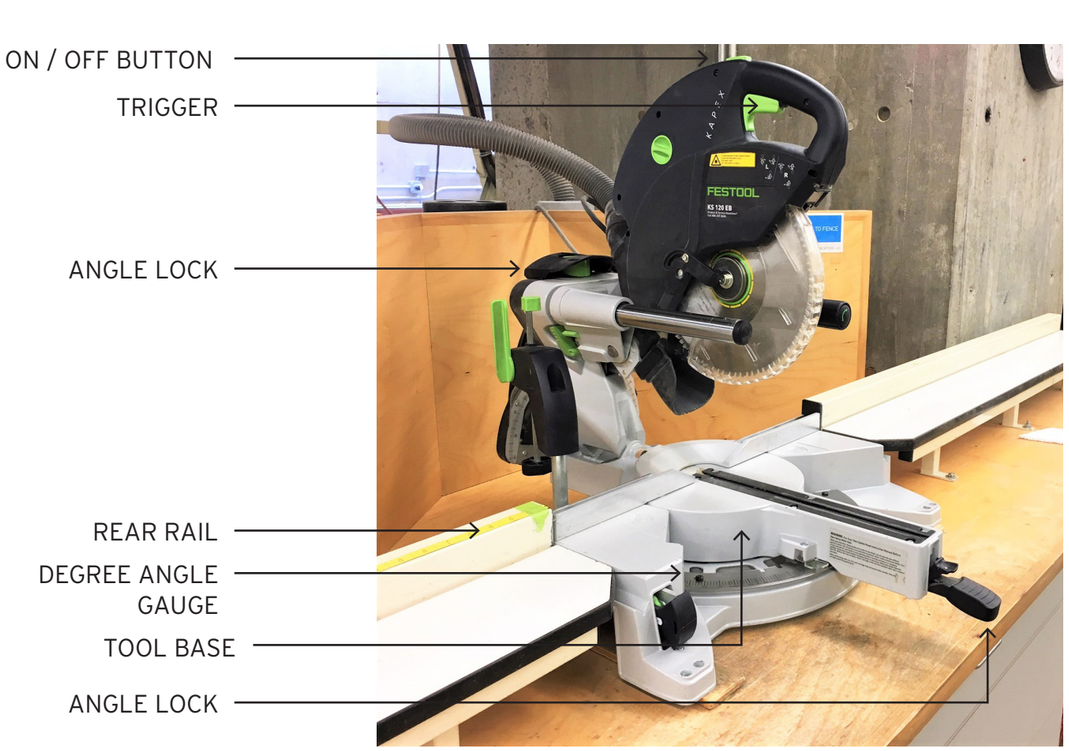
To make a cut I will stand slightly to the side of the saw. Being right handed I prefer to stand to the left but either side is fine. To fully lower the blade into my material I will have to squeeze the green trigger under the handle; if I don't do this the blade will not fully lower. Once I am ready to cut, I will maintain contact with the trigger and press the green button on top of the handle with my thumb. This will power on the saw. It will remain on until I release the trigger.

Before cutting, I will set my stock in place with the flat side held down and the straight edge firmly against the rear rail. Hand pressure is all that is required to maintain control of your stock. To the

side of the cutting point on the body of the saw there is a small diagram of a hand with a line through it. This is a reminder that your hand should be at least that far away from the blade when cutting. If it is necessary to cut something smaller than what your hand can safely hold you should either use a different machine or ask a staff member/TA for assistance in holding your stock.

When cutting there is a specific way I would like you to move the blade. Some similar saws only work by pivoting and others only work in a linear motion. We have the option here of both and I would like you to use both to cut in waves. By that I mean move into the cut about a quarter or third of the way through and then retract up/completely out. Move back in a bit further and repeat these motions until you have cut all the way through. 3–4 waves should be enough for almost any cut this tool will make. We will discuss why cutting in waves is preferable in a minute, when we discuss cutting warped material.

Basic cuts are made in this way: our material is held firmly in place so it cannot move, the saw is set to its standard position, and the blade is pushed through the material in those 3–4 waves until it is completely cut through. This will give us very clean 90 degree cuts. We are, in essence, chopping material to specific lengths and this type of saw is sometimes refered to as a "chop saw". Its proper name, though, is the compound miter saw because it can easily set up double angled, or compound, cuts. Let's examine the process of setting up a cut like that.



To angle the first plane of the saw I'll grip the black handled extension on the front of the tool. Gripping it tightly from above and below will release the lock and allow rotation of the saw body to 45 degrees both left and right. There are indents set to common angles and the saw will click into those if allowed. It can also be set to any intermediate angle and locked in pace by pressing down on the large black handle. To set the second angle, reach behind the saw and lift up on a black paddle lever. Once it is up you can rotate the saw body side to side either by hand or by twisting the extension of the righthand linear rail. With that angle set accurately, re-lock the rear black paddle lever to hold the angle.

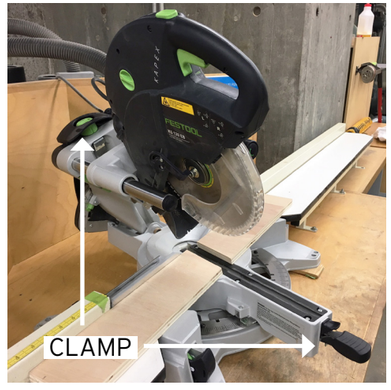
Cutting is accomplished in the exact same way as it is with a standard chop cut. Hold your material firmly and cut in waves. You should get the same beautiful clean and straight edge you would with a perpendicular cut. When your angled cuts are complete return the saw to its set position.

Angle cuts like these are easily accomplished on the miter saw; it is designed to quickly make these types of cuts. We could also make them on the table saw by angling the blade and using a miter tool angled in reference to the plane of the blade. As with most circular saw tools, the table saw will allow us the greatest precision. The mass of the tool, the sturdiness of the trunnion and spindle all contribute to a greater level of precision. The miter saw can make these cuts much more quickly than the table saw can but, if they need to be perfect, it is worth spending the extra time to set it up on the table saw.

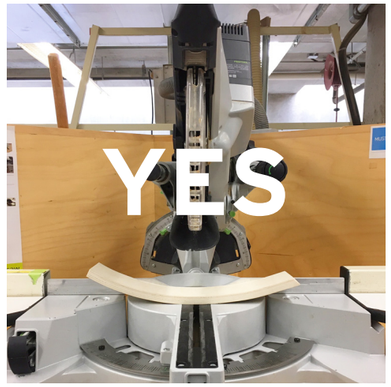
Let's return to the reasons behind cutting in waves- we are looking to avoid kickback. Kickback on the miter saw is different than on the table saw; the cutting force is directed away from us whereas with the table saw it is directed back towards our bodies. Rather than material being thrown from the saw, kickback on the miter saw involves the saw blade and body being forcibly ejected from the cut. This isn't as dangerous as kickback on the table saw. The saw body is ejected backwards but it doesn't come off of the rails, the blade guard will still immediately retract, and the danger to our bodies is minimal. It is, however, something that shouldn't occur if we are being deliberate about our work and accurately predicting what will occur when we engage with a power tool. It is a loud, sudden, and violent motion. It is something that should be avoided in conscientious work in the woodshop.

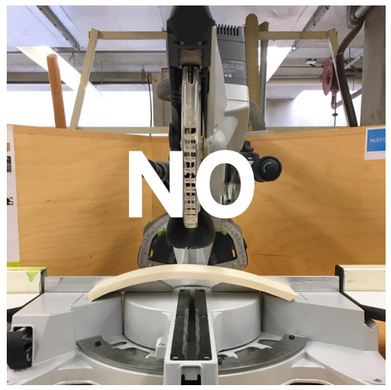
Why does it happen? And how does cutting in waves help to alleviate the possibility of it occurring? To answer this question lets investigate what happens when we cut warped material.

The most common general use of a saw like our miter saw is to cut 2x4's to length. 2x4's are general construction lumber,



SETTING A COMPOUND ANGLE





POSITIONING WARPED STOCK

roughly 2 inches by 4 inches and 8 feet long. They are used in all manner of construction, most commonly in the standard framing of a home. In general, it is safe to assume that most 2x4's are not flat and straight. They are cheap, processed and dried quickly, and simply do not need to be perfect for their intended use, especially as they are often doubled up for strength. On the table saw, we are extremely picky about our material and wouldn't cut something that isn't very flat and very straight. On the miter saw, though, one of its most common uses is cutting something that is rarely perfectly flat and straight. We need to make some allowances– lets examine how to evaluate warped material for safe use on the miter saw.

Lets imagine we have a board that is warped in one plane only. And let's set that board up on the miter saw so, from the front, it looks like a frowning face, with the ends touching the table and the middle (where the cutting point will be) slightly up in the air. If we begin to cut this board, we will be weakening it and it will likely begin to sag as a result of this. If our blade is buried in the cut when it begins to sag the blade will be pinched from the sides as our stock closes in on it. We talked about avoiding contact with the sides of circular saw blades when we introduced them. This is exactly what to avoid if we are trying to avoid kickback on the miter saw.

To remedy this, let's simply flip the board over. With the center of the board locked in place and the ends up in the air a similar cut (and similar sag) sees the ends move down and the cutting point open up, with the stock pulling away from the blade instead of closing up and pinching it. If we repeat that example with the board warped in the other direction (with the smile/frown visible as we look down on the tool) we see the same issues.

What is obvious from this is that we need to be sure to recognize when our material is warped; material selection will always include sighting down the length of the board to identify any areas of warping/twisting before placing the material on the surface to be cut. If it is warped, we want to be sure that the board is placed on the tool so that it is firmly locked in place (in the flat and straight planes) right at the cutting point. If so, when cutting commences any movement in the board should move away from the blade and mitigate the pinching that would cause a kickback event.

So, then, if a kickback event is limited by careful evaluation of our stock and a deliberate intent to lock it in place correctly, why do we still need to cut in multiple waves? For the same reason that we are suspicious of solid wood on the table saw- we cannot trust that the material will remain stable once

CLAMPING ROUND STOCK

we begin to cut it. Especially when we are dealing with construction lumber like 2x4's, the expectation that there is some level of instability in the material is almost a given. Even a piece of material that appears to be perfectly flat and straight can move while being cut. If we cut in waves we allow for it to close up slightly while our blade is retracted. When we enter again we are slicing through where it has already closed up. Each time we do this, we limit the overall force it has to overpower the tool and we reduce the possibility of a kickback event.

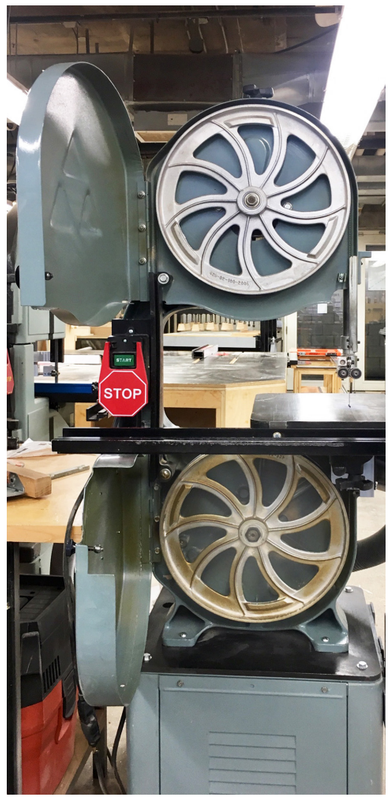
A few other things to mention on the miter saw– we can cut aluminum on occasion with this tool. We don't cut large pieces, but if there are thin walled extrusions the tool can be set up to cut them quickly and cleanly. If you would like to do so please ask a staff member or TA to help you set up the tool correctly. This usually involves both clamps and a blade lubricant to stop the aluminum from sticking to the teeth.

If we are cutting large (and especially hollow) round stock it needs to be very firmly clamped in place before cutting can begin. Anything less than 1" in diameter is generally cut through so quickly that it won't begin to spin. If larger round stock begins to spin (and the rotation of the blade exacerbates this possibility), you will lose control quickly and create a very dangerous situation. Clamp your stock firmly to the rails, preferably at an angle into the corner and only then begin to cut them through.

BANDSAW

Up until now, we have looked exclusively at machines that use the circular saw blade and, as such, will only allow us to cut straight and clean lines. We need to be able to cut curves and other organic shapes, though, and will need tools that allow us to do that. The bandsaw is the most obvious tool to allow us that option.

Looking at the bandsaw with the doors open, we can see two wheels and a blade wrapped tightly around them. The blade is one long band and that is where this tool gets its name, the bandsaw. The lower wheel is mounted to a shaft which extends through the body of the tool. On the other side of that shaft, behind a guard, there is a pulley that connects to the motor using a belt. When we power on the motor, located within the base of the tool, it powers the lower wheel. The top wheel is free to spin and can also move up and down. We lower the top wheel to mount the blade and then raise it to tension the blade. The tensioned blade transmits the power from the lower wheel to the upper wheel and the extreme tension of the blade keeps it from slipping as we use it to cut through our material.



BANDSAW INTERIOR

With the doors closed, we can see the exposed blade visible above the main work surface. If we look at the blade teeth and understand how it is spinning, we can see that the cutting force will be downwards and towards the table top. Knowing this, we can understand that there isn't a danger of the tool throwing our material out of the saw. If the blade does catch our stock instead of cutting it, it will simply force it down onto the table. Safe use dictates that our stock is touching the table at all times, we should never attempt to fully freehand cut anything that isn't using as much of the table as possible as a reference surface.

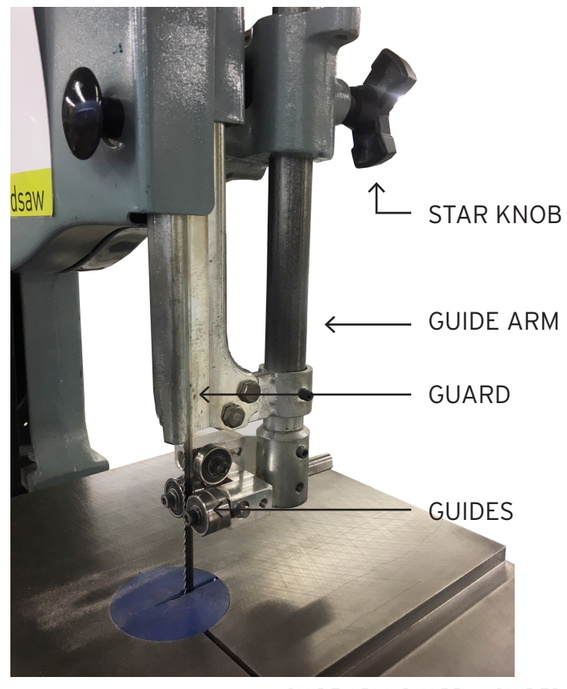
As our stock sizes change we should adjust the guide arm so that the guides are situated just above our stock (anywhere from 1/4" - 3/4" is acceptable). To set the guide arm unlock the black star knob on the backside of the bandsaw. Make sure the machine is off and the blade is not moving before doing so. Hold the guide arm when loosening the knob as the guide arm will fall when loose. Raise or lower the guide arm so that the guides are the proper distance above your stock.

With the guide arm in place the blade guard is now set to limit our exposure to the blade and the guides are in place to help us cut with precision. The bandsaw blade, by itself, is not very rigid. I can easily move it side to side and twist it, even under normal operating tension. This is necessary for it to cut as we need it to; if we are to cut along curved lines we must allow for the blade to twist in the cut and follow the line we are attempting to cut. If it moves too much, though, it can be very difficult to follow our line. The blade will wander and we may struggle to predict where it will be as we are cutting. The guides provide some limiting factor to keep the blade within a set parameter while still allowing it the space it needs to twist and follow our curved cuts. Moving the guide arm into the correct position will help us cut quickly and accurately and keep us safe from the exposed blade.

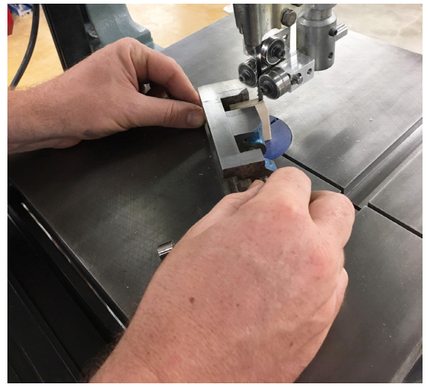
To make our cuts we will position our stock firmly on the table surface and push it forward into the blade. It is common to either draw lines or adhere a printed paper surface to the top of our material. In most cases, the goal is to cut as close to our lines as possible without going over and to then take our cut stock to the sanding machines to both smooth out the cut surfaces and bring the edges right to the line we originally defined. The bandsaw will always leave a slightly rough cut surface, it will not resemble the cleaner cuts we achieved on the tools that used the circular saw blade. There will be slight striations on the cut and variations as the material density and our feed rate change. The workflow of cutting on the bandsaw and then moving to the sanding machines is one of the most common in the woodshop and we will move to the sanding machine and clean up the cut edge after this.

Injuries on the bandsaw are most commonly caused by our hands being too close to the blade when cutting. There is a slight risk of the blade snapping during use but the most common injury seen is from careless procedure and moving your hand into the blade while making small cuts.

The bandsaws are the most used large tool in the woodshop and it isn't uncommon to see someone use them for many hours a day. This frequency of use can give the user a fair amount of confidence and that is good; I hope that you spend enough time using these tools to gain the confidence repeated use allows you. It will greatly benefit your work in the Lab. Sometimes, though, confidence can breed carelessness and most of the accidents we saw on the bandsaws were accidents of simple carelessness. With that in mind, we instituted a rule that your hands should never be within a 3" diameter circle that surrounds the cutting point of the blade. If we do see your hands get that close we will stop you from working and remind you.



GUIDE ARM, GUARD, + GUIDES



(LEFT) USING THE TOOLMAKER VISE; (RIGHT) ALL SHOP BANDSAWS

Sometimes it is necessary to make a cut that necessitates control of small material within this 3" circle. We are able to make that cut, we just cannot use our hands as the method of control. Any other method of control is an option; a wrench or small clamp can work and we supply small toolmakers vises specifically for this purpose. If you need to make these exacting cuts on small sized stock please ask either a staff member or shop TA for assistance.

As on the table saw, there are both fences and miter gauges available for use on the bandsaw. Do not assume, though, that they provide the same level of control when moved from tool to tool. They work so precisely on the table saw because the blade is so rigid. On the bandsaw, the blade is looser and prone to drifting slightly side to side as the guides will allow. No matter how perfectly you set up the fence, or any tool that may ride in the miter slot on the bandsaw, you are not guaranteed the same level of parallelism or perpendicularity that you are on the table saw. In almost all cases, drawing a line and freehand cutting to that line is the recommended way to use the bandsaw. Even when cutting straight lines.

We have four bandsaws clustered together in the shop and they are all set up slightly differently. Three of the saws have blades designed to cut standard woodshop material- wood, MDF, foam, etc... The saw we have been using and the one next to it are identical except for the size of the blade; a thinner blade will allow for a tighter curve to be cut. The larger green saw has an almost identical blade but the size and power of the saw allows for much larger material to be cut easily. You might use the larger saw if you are cutting a model base that is either large or heavy, if the material you are cutting is very thick, or if the guides need to be raised higher than the smaller saws will allow. The saw painted a more mint green is setup with a blade designed to cut harder materials; we use it primarily to cut aluminum and plexiglass. Cutting wood with that blade can cause the wood to start to burn, and smoke. It is labeled clearly that it is specifically for harder materials.

Like on the miter saw, we have to be careful when cutting round stock. The lack of a flat face on round stock means that the risk of it beginning to spin when in contact with the blade is very high. If it does begin to spin you will quickly lose control. For any wood material larger than 1" in diameter, the stock must be clamped to something that will stop it from spinning. A miter gauge is the most common option. Please ask for assistance if you are not sure how best to control your material.

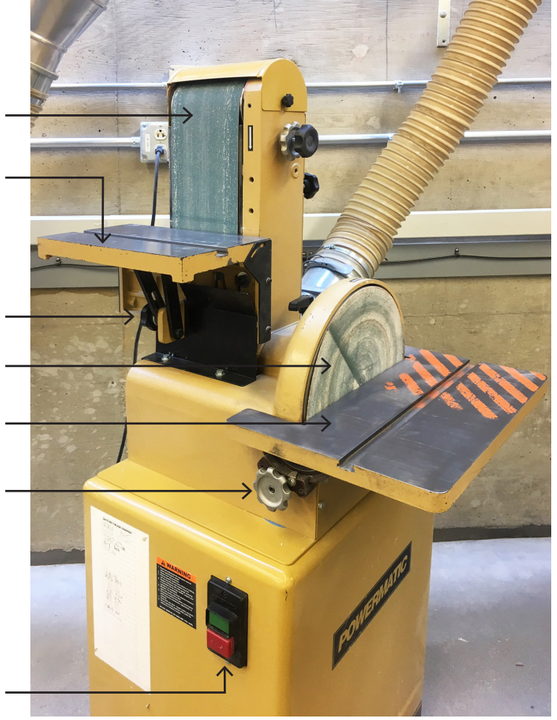
SANDING MACHINES

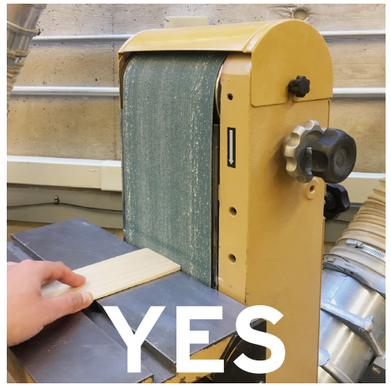
Most students who pass through the GSD woodshop have at least some experience with basic sanding. It is common that students have at least manually sanded material and this process is considered relatively safe; there is little risk associated with using sandpaper manually. With our powerful sanding machines, though, that process becomes more dangerous and care must be taken to ensure it is done safely.

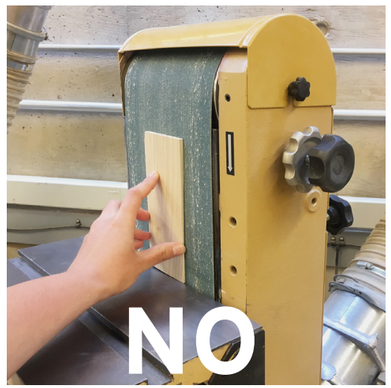
The biggest difference between using sandpaper by hand and using a sanding power tool is that a powerful motor is driving the abrasive. The type of sandpaper is also different- Sandpaper we might use by hand is generally paper based; the abrasive is bonded to a paper material that can rip or tear easily if it encounters too much resistance. The cloth belts and discs used on the sanding machines are much stronger and can withstand greater resistance before failing. This, combined with the electric motor as the driver of this stronger belt, means that we are dealing with a powerful tool designed not to fail when encountering extreme resistance.

A sanding belt doesn't always appear as dangerous as a blade; the surface isn't obviously sharp, and may not command the respect that a sharp blade might. It is just as dangerous, though. It is cutting at a microscopic level and if your body comes in contact with the sanding belt while active it will immediately remove skin. Safe use of the sanding machines requires us to understand and appreciate this, and always maintain a safe distance from the abrasive surface.

We will be focusing on the belt and disc sander in this orientation and this machine combines both options into one machine. When the tool







USING THE BELT SANDER

is powered on both will begin spinning, there is not a way to separate them and power only one at a time. Both the belt and disc have arrows showing the direction they are rotating and this helps us understand where the force is directed. On the belt sander, the force is directed downwards and, like on the bandsaw, our stock must be making firm contact with the sanding table before it contacts the abrasive belt. The disc spins counterclockwise, and the safety paint on the disc sander table is there to remind us to work on the lefthand side of the table. On that side the force of the disc is downwards as opposed to up on the righthand side. Having to hold our stock down while the disc is trying to pull it up is both cumbersome and unsafe. Working on the lefthand side of the disc sander table alleviates this problem.

The most dangerous point on the sanding machine is the small gap between the abrasive surface and the table. This means that very thin material, or even thick material with an edge that tapers to a point, should never be presented to the sanding surface in a way that could wedge a thin edge in the gap. If it does, it will immediately lead to a violent event that pulls the material into the gap and damage either the material or the machine. In a worst case scenario, it can pull/pin parts of your hand into the abrasive surface causing serious injury. Keep this in mind when dealing with any material that has a thin edge.

Any sanding done on these machines should be considered a smoothing operation rather than a shaping operation. Every attempt should be made to cut your material as close as possible to its final size before bringing it to the sanding machine. While the sanding tools are capable of doing extreme rough shaping it isn't an ideal way to use them as we are always looking to avoid excess force and heat buildup. These can prematurely wear the belt, causing it to drift side to side and damage the body of the sanding machine. It can also cause your material to heat up and, with the end grain of wood especially, leave deep burns on the sanded edges. It can also cause undue wear on the metal backing plate behind the abrasive surface. We rely on that plate to be flat; when we press material into the belt, the belt is conforming to the shape of the plate behind it; the belt has no true shape of its own. If the plate behind the belt is no longer flat from wear, we won't be able to sand flat planes onto the face of our material.

Proper sanding technique includes light to moderate force and to use the entire surface of the belt or disc. Moving side to side and modulating pressure (short bursts of force instead of long, prolonged contact) will help to dissipate heat and prolong tool life and leave you with an optimal sanded surface. This applies to all of the sanding machines available for use.

As with most of our other tools, the dust collector will power on automatically when the sanding machine is activated. The dust is pulled into the body of the sander and then evacuated through the metal ductwork above the machines. The dust collection works very well and you shouldn't experience excessive dust buildup either on the tool or in the air while sanding on these machines. If you do notice excessive dust, turn the machine off and alert a staff member or TA; something is not working correctly if this occurs.

Our sanding machines use moderately rough grit belts and discs and work well when sanding materials like wood and foam. It is permissible to sand plexiglass although the sanded edge off of the abrasive belt is not comparable to the very clean edge off of the laser. No metal of any kind can be sanded on these machines as the hot chips and possible sparks must not be allowed to mix with the flammable wood dust in the dust collector. Common casting materials such as plaster and concrete are also not allowed on these tools. The abrasive dust can prematurely wear the tool and the abrasive surfaces can clog almost immediately if the material isn't completely cured.

There are multiple sanding machines available for use. The two identical belt and disc sanders are the most used sanding machines. A larger disc sander is available for oversize material or more aggressive stock removal. A horizontal edge sander is used almost exclusively for sanding long edges that won't fit on the smaller machines. We also have a spindle sander which uses a spinning drum rather than a flat surface. That tool is wheeled out as needed and will allow you to sand inside curves, something the flat faced machines are not capable of doing.

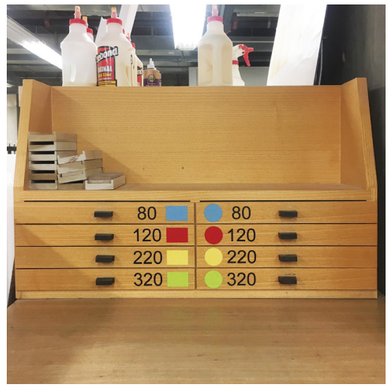
DOWNDRAFT TABLE

Not all sanding operations can be accomplished on a stationary power tool. Many times, what needs to be sanded is either too big or too small to be safely or realistically sanded on these machines. In those cases, we need to use handlheld options.

Dust collection is a serious health issue and we need to be sure that we are not creating a dangerous workspace both for ourselves and those working around us. Our dedicated sanding machines have dust collection built in but we will need to use our downdraft table when sanding by hand. This includes both sanding with powered hand sanders and when simply using sandpaper by hand.

The downdraft table is a surface with downward air flow. Air is pulled into the machine through its slotted top surface, filtered inside of the machine, and then expelled as clean air from below. The tool moves a large volume of air so, while the air flow may never feel as intense as at the nozzle of a shop vac, it is moving enough air to capture the fine dust particles created from sanding. All sanding in the shop must take place on this surface; even quick hand sanding should be done here and not anywhere else in the woodshop. This is true whether you are working alongside many other students or are the only active user in the space.

The downdraft table is powered on with a control box on the side. Turn it on before beginning your work and leave it on for the duration of your sanding operation. There are electrical outlets hanging



DOWNDRAFT TABLE + SANDPAPER

above the downdraft table that will allow you to plug in both orbital and palm sanders. These handheld powered sanders are located in the wooden cabinet across the aisle from the downdraft table. Sheets and small sandpaper discs are also available in the cabinet. We supply four grits: 80, 120, 220, 320 in both sheet and disc forms. These will always be replenished; you will not need to purchase sandpaper unless you are working outside of these four grits.

Please take care not to let any sharp materials fall into the downdraft table. We rely on the high efficiency filters in the body of the tool to remove the dust from the recycled air. If a razor blade or sharp screw happens to fall in and puncture the filters we will no longer be cleaning the air and will create a dangerous environment for everyone in the shop. The downdraft table surface can be used as a work surface if all others are being utilized, but no sharp objects should be placed on top of it. And if someone requires the downdraft table for a sanding operation that is always its first priority.

TOOL STORAGE

Located directly next to the sandpaper storage cabinet is our main small hand tool cabinet. Here you will find tools such as wrenches, pliers, screwdrivers, handsaws, hammers etc.... These are all here for you to use within the woodshop. Please do not take these out of the shop, we have separate tools that are available for checkout. These should all be here and available when needed.

The cabinet has a safety mechanism that limits it to having only one drawer open at a time. If the drawer you are attempting to open feels stuck it is likely because another is very slightly ajar. Push that one in, and the drawer you were having issue with will open easily.

Around the corner from that large cabinet is a smaller wooden one with two wide drawers and a wooden top surface. Tape measures are available on the top of this cabinet and pencils, a sharpener, and tape are stored above. In the drawers are razor blades and scissors. Below you will find a large roll of white butcher paper. Immediately to the left is a bin full of rags. The rags are for you to use; like the nitrile gloves the rags do not need to be used in the woodshop. You are free to take what you need and we will always replenish the stock.

Behind the TA desk is a brown tool chest with some specialty tools. TA's control this tool cabinet, please do not open these drawers and take the tools out yourselves. Ask the TA on duty for assistance and they will get them for you. When you are done using the tools return them to the TA on duty. Tools located in this cabinet include items like calipers, angle gauges, inflation tools, chisels and handplanes, awls, carving tools etc... These are primarily either higher cost or more delicate tools and we prefer to keep a closer eye on them and/or monitor their use.

All of our wood chisels are stored in this cabinet. It is my opinion that if we ever have a serious injury occur in the woodshop it will be with a chisel or a sharp hand tool very much like it. You are welcome to use the chisels but expect a TA or staff member to observe your use until we feel comfortable you appreciate the danger inherent in such a razor sharp tool.

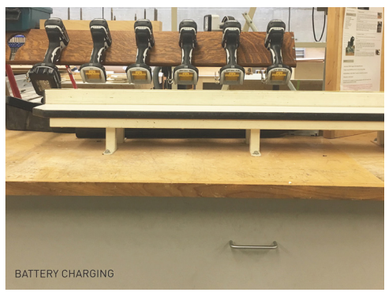
Next to the brown cabinet is our collection of borrowable tools; these are able to be checked out for a period of two days and used outside of the woodshop. Our borrowing protocol is similar to the library; you will sign a form and agree to return the tools within two days or face a fine. Most of the tools students have requested to borrow are represented in the borrowable tool cabinet. The most popular items are cordless drills, sets of clamps, setup blocks, screwdrivers and digital scales etc....

Across from this cabinet are the cordless drills. Available drills are displayed next to the chop saw and batteries are kept on charge in the drawer directly beneath. These drills are to be used in the woodshop only, please do not take them out of this space. Drivers for the drills can be found either on top of the display or in the hand tool drawers. Drill bits (for making holes) are found by the drill press, the tool we will examine next.

DRILL PRESS

The drill press is the last large machine that we will introduce and the drill press is used to make round holes in many different materials.

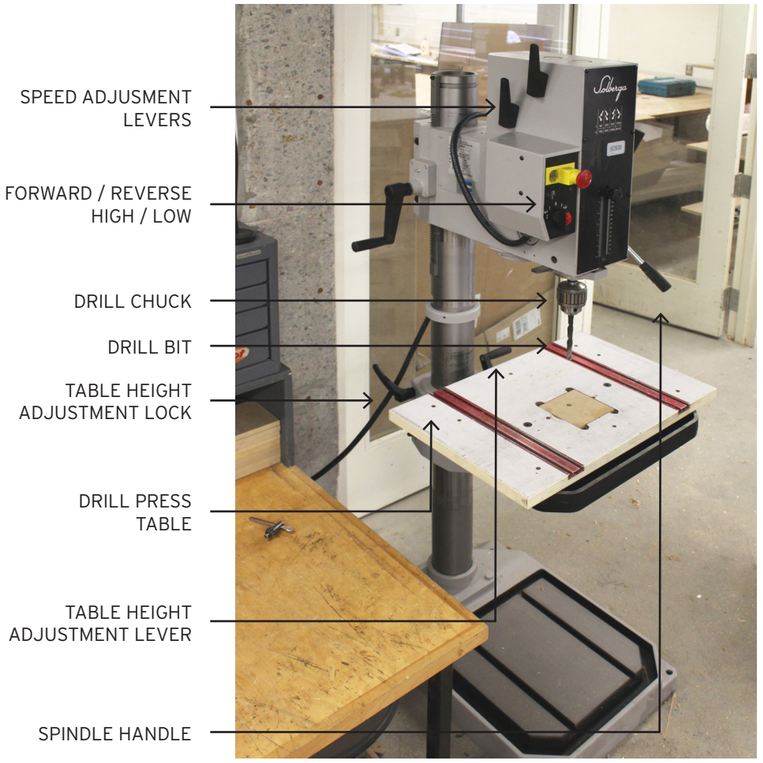
When you approach the drill press you will need to know a few things; what size holes you would like to make, where you would like to make them, and which bit is best for the size hole and your specific material. Some of this you may know and some you will likely need assistance with.



TOOL DRAWERS IN THE WOODSHOP

If the hole that you would like to make is between a pinhole and 1/2" then your most likely choice on drill bits will be a twist drill. A twist drill is a very well designed tool; unique among many of the cutting tools we have looked at today, it is equally comfortable drilling holes in soft materials like foam as it is drilling them in mild steel. The geometry of the drill is as such: the end of the twist drill is solid, and round. This is where we will grip the drill bit. Below that begin the flutes. The flutes are spiral shaped grooves that begin at the solid section and extend down to the tip of the drill. The flutes are there to allow for the material being drilled to exit the hole. As it is bored by the tip it travels up the flutes and blossoms out the top of the hole. The tip of the drill bit is the only truly sharp part of the drill bit. The edges of the flutes appear sharp but they are not truly sharpened to a fine edge in the same way that the tips are. Looking closer at the tip we can see that it is tapered. This helps it to locate the center of a hole and allows it to center itself as it begins to drill. It is also an easy way to differentiate a drill bit from an endmill, which can look extremely similar to someone not used to the difference. Most endmills will have a flat bottom, instead of the tapered tip of the drill bit.

We have full sets of the basic imperial sizes of drill bits, from .04" (approximately 1mm) up to 1/2", or 12.7 mm. There are three separate groupings of bits, factional sizes, wire gauge sizes (1-60) and letter sizes. There is little overlap between these three designations and. When combined, they form an extremely complete set of sizes up to 1/2". They are all housed in the grey cabinet next to the drill press.



Proper procedure on the drill press begins with loading your drill into the drill chuck. There are different styles of drill chuck and we use a standard style on our stationary drill press. You can see that it has a row of gear teeth around its lower edge and there is a chuck key that has a matching set of teeth on it. It is necessary to use this chuck key to fully tighten the drill chuck; hand pressure is not adequate when using this powerful tool. Some drill chucks do not have the gear teeth and are able to be tightened by hand pressure only. Our cordless drills operate like this. On the drill press, though, you must use

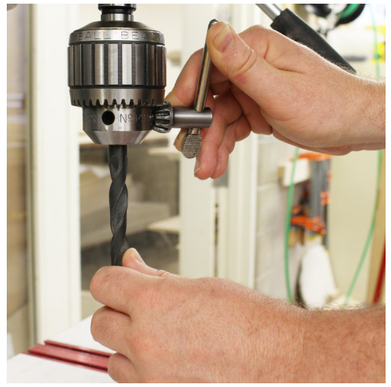
DRILL BIT STORAGE

the chuck key. It can be found in the bottom drawer of the grey cabinet.

The drill chuck has three jaws it its tip. Rotating the sleeve will either open or close the jaws; open them until your drill bit fits within the three jaws and then close the jaws until your bit is held tightly. It is possible to grip the bit off center- rotating the chuck by hand should be enough to see that the bit is not held on center. Once your bit is installed correctly and snug tightened by hand use the chuck key to completely seat the jaws around the bit.

With your bit installed, you can set the speed of the drill. Consult the chart on the wall and locate the closest possible approximation of material, bit size, and bit style. This should give you one of the 8 available speeds on the drill press and it is in your interest to set the drill press correctly for your operation.

Setting speeds on the drill press requires manipulating the black levers on the upper lefthand side of the drill. Consult the chart on the front and then match that configuration with the levers on the side. The levers cause different configurations of gears to mesh inside of the drill press head and it may be necessary to slightly rotate the spindle by hand to get the lever/gears to engage. You will feel when it is engaged.



DRILL CHUCK & DRILL OVERHANG

With your drill bit installed and the speed set correctly, we can set the table depth. There is no perfect distance between your drill bit and your material. It only needs to be close enough so that it can drill through. The quill can travel 6" vertically so the bit could begin well above your stock and still be at an operable height. If you do wish to adjust the table height, begin by unlocking the lock lever on the lefthand side of the drill press behind the table and next to the main column. Rotate it counterclockwise to unlock. It may take some force to loosen it from its locked position. Once it is loose, rotate the handle on the righthand side to raise or lower the table. Clockwise will raise the table and vice versa. Always relock the table when it is at its intended height. When the table is unlocked it can also be rotated side to side.

In the middle of the drill press table is a square cavity that should be filled with a square block of MDF, a homogenous brown board material. It is important to have a solid section of this backing block directly underneath your material. When the drill exits the backside of your material it is preferable to have solid material there so the bit won't "blow out" the back of your material and tear the edges of the hole. Look at the MDF block and see if it is solid where you will be drilling. If not you can flip, rotate, or replace the block. Extras are always available under the grey cabinet to the side of the drill press. These blocks are considered a consumable- do not hesitate to use them as necessary.

When positioning your material on the drill press there are a few things to consider. Depending on what you are drilling, you may need to secure your material with more than hand pressure. Drilling softer materials like wood, plywood, and foam, does not require clamps. Firm hand pressure holding your material down to the table surface is acceptable. When drilling harder materials, though, you will need some sort of mechanical assistance. Materials like plexiglass, aluminum, and steel will need to be clamped in some way. There are clamps available for holding material down to the tabletop above the grey cabinet. There are also heavy vises below the cabinet/table that can help support your material. Clamping material helps to keep it stationary when you are drilling. There is a danger of the rotational forces ripping the material out of your hands. If that material is sharp, or very heavy, it can be extremely dangerous.

For this reason, we also pay careful attention to any overhanging material. If we are drilling off of center on a long piece of stock it is important to arrange the longer section of the overhanging material to the left. The reason for this is that if the spinning drill bit catches the material and starts it rotating as well, the material on the left would be quickly rotate into either the column, the grey cabinet, or the wall, depending on its length. If it was on the righthand side it would rotate into your body and could cause serious injury. Even with softer and informal materials like wood and foam it is still necessary to arrange the longest overhanging length to the lefthand side.

With everything in place we are prepared to drill our material. Power the machine on and slowly bring the spinning bit into your material. For shallow holes you can drill through in one motion. For deeper holes it is advisable to peck drill, or move in and out in short bursts to make sure the hole is cleared of excess material and heat buildup.

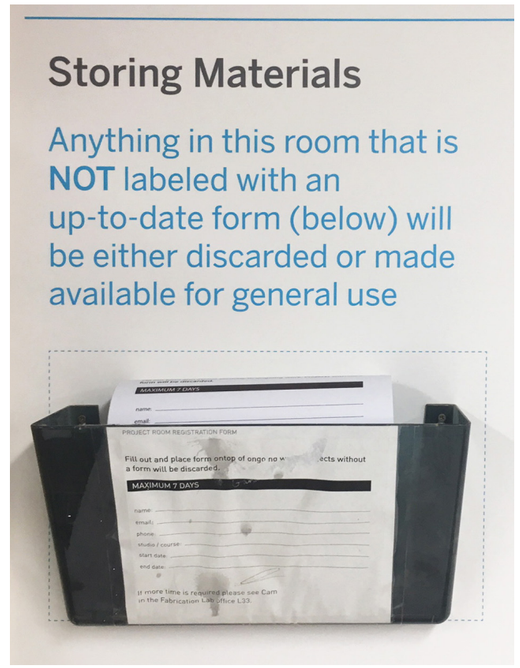
When your drilling operations are complete remove the bit and return it to its correct storage bin in the grey cabinet. If you do not remember exactly which bit you have used, leave it on top and a TA will return it to its correct spot. Take care to NOT leave the chuck key in the drill chuck- it belongs in the lower drawer of the grey cabinet.

PROJECT ROOM

Adjacent to the woodshop is a smaller work space called the project room. This is a 24 hour space and is the main after hours work area for the entire school. Having taken the online trainings/quiz and attended the in person woodshop orientation your card will allow you access to this space 24/7 from the rear doors. It is common that, once the woodshop closes, students borrow tools and move their materials into the project room to continue working.

You are welcome to store materials in the project room with some caveats. We welcome storage of materials for projects that are current and will be worked on over the course of ~1–2 weeks. It would be helpful if we had the space to store materials long term, or even the ability to store completed projects. Unfortunately, though, as this room is shared space for 900 students, we do not have that ability and we can only support storage of current work.

A completed storage form should accompany anything you wish to store in this space. These forms are supplied in a bin on the long wall and should be filled out completely and adhered to your materials. TA's check all stored materials for up to date forms and, if overdue, you will receive 1 reminder before we either discard your materials or move them to the scrap pile. Please respect this



PROJECT ROOM FORMS

PROJECT ROOM SINK + SPRAY BOOTH

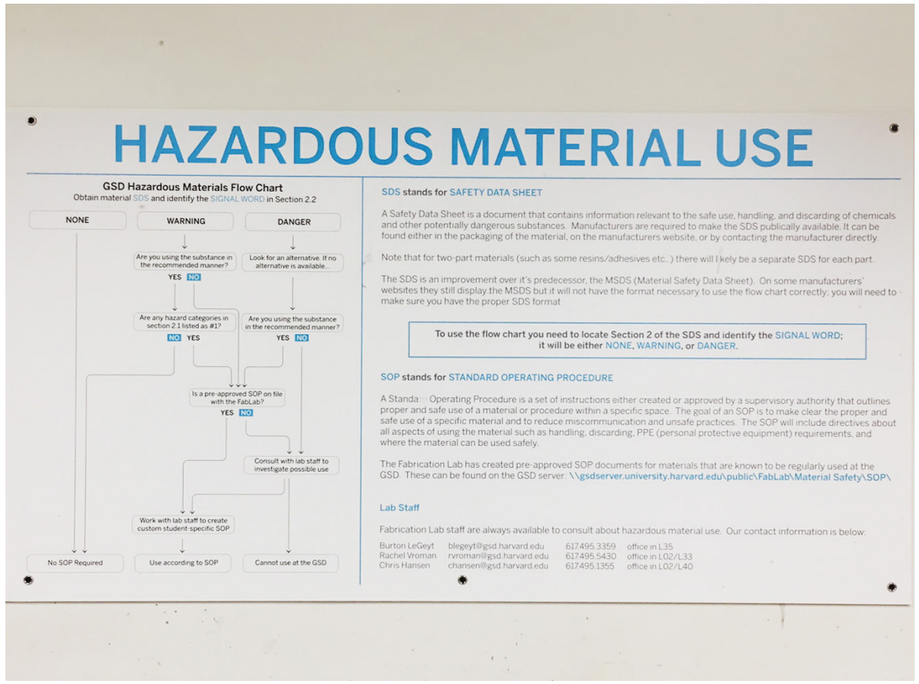
process and understand that we make the best out of the space that we have.

There is a sink in the project room which is used often, especially when doing water based casting. Please take care that **NO WATERBORNE PARTICULATE** goes down the drain. This includes obvious material like concrete and plaster but no paint should go down the drain either. If you need to clean out a bucket or clean a paintbrush, please do so in a satellite container (of any kind) and pour that contaminated water into the collection bucket (with yellow funnel top) to the side of the sink. This water will be collected and disposed of properly. If the sink gets clogged it can delay everyone's work and, in a worst case scenario, overflow.

We have reminders up around the school displaying the flow chart that aids in making informed decisions about hazardous material use. You will all have to complete the hazardous material training to gain access to these spaces. These rules apply to every space within the school and the project room is no exception. If you are found using hazardous materials improperly, you will receive one warning. If you are found breaking protocol a second time you will lose Fabrication Lab privileges. Be reminded that ANY material you might wish to introduce to the school must go through an SDS examination on your part. If you are not sure how to do this yourself, reach out to a staff member for assistance before bringing that material onto school grounds. There are no exceptions regarding disciplinary actions for ignorance of the system.

Materials that have been approved or have a pre-approved SOP on file (such as most spray paints/adhesives) can be stored in the yellow cabinet in the project room. Label them well– unlabeled materials in that cabinet are considered for general use and may be used by anyone.

There is a small spray booth in the project room. To utilize this booth you will need to turn the main fan on using the black switch on the wall. It may take up to a full minute for the pressure to build up to the point that you can feel it in the booth. Wait for that before spraying anything in the booth; you should never contaminate the air until you are sure it is being safely drawn away from you. There are storage shelves under the main surface in the spray booth and you are encouraged to let your work off gas on these shelves. If this may take time, you can leave the booth on while your material dries. So others can also utilize the booth, please make use of these lower shelves and do not leave your material on the main work surface while it dries.



The door to the metal shop is off of the project room. The metal shop schedule changes semester to semester depending on our TA team. We try to be open each evening and each weekend day. You do not need to attend a separate metal shop orientation to use the space, you will always be working under direct supervision. We do offer introductory sessions in the Spring semester but they are to introduce the tools and are not mandatory. Look for those to be advertised in the student announce email listing.

CONCLUSION

This completes our woodshop orientation. We look forward to seeing you in the shop. If you have any questions please ask either a staff member or shop TA during open hours. Outside of those hours you can email all the TA's at woodta@gsd.harvard.edu or Burton at blegeyt@gsd.harvard.edu.