

NEVER RUN THE LASER UNATTENDED

Fire!!!

In normal operation of the laser cutter, small flames may be created underneath the cutting head. These small (birthday candle size, < 1 cm) flames should quickly be extinguished by the compressed air running through the cutting head. If these flames persist or grow you must stop cutting **immediately** and **extinguish the fire**.

1. Pause cutting and crack the lid of the laser cutter
2. If fire persists, blow out fire with compressed air (nozzle to left of laser cutter)
3. If fire persists, extinguish fire with CO2 fire extinguisher
4. Tell us so we can help you adjust settings and confirm the laser cutter is ok

Failure to operate the laser cutter in accordance with these rules will result in **loss of privileges**.

The laser can spontaneously ignite vaporized plastic, burn wood or paper. Our neighbors at MIT and the Artisan's Asylum both suffered serious laser cutter fires.



Always be prepared for a fire



Above left is an example of an unacceptable flame. If this flame does not disappear when the head moves away you must **stop cutting and deal with the fire**. Opening the lid or hitting the pause button will disable the laser. This is often enough to stop a candle-size fire.

Small fires can be blown out with compressed air (see the air gun above middle hanging off the black tubing). Ensure that it is within reach. Wear safety glasses or turn away to avoid blowing debris into your face.

If the air doesn't work, use the CO2 fire extinguisher (above right) mounted across from the cutter. It leaves no mess. If a fire doesn't blow out, use it!

If all else fails, exit the shop and pull the fire alarm located down the hallway towards the elevators.

Laser cutting session checklist

- Your material is suitable for cutting
 - Your design is compatible with cutting
 - Exhaust is working
 - Air assist is turned on
 - Laser cutter is powered on
 - Material is laying flat on the honeycomb and is positioned against the guide rulers
 - The honeycomb is correctly seated in the machine
 - Your design is positioned at least 0.2" away from the edge of material
 - Lines to be cut are pure red and hairline
 - Lines to be etched are pure black and are not hairline
 - Your power, speed and ppi settings are correct
 - Your z axis setting matches your material thickness
 - You are prepared in the case of a fire (air blowgun and fire extinguisher are in reach)
 - You are prepared to watch the entire cutting session
 - Proceed with cutting
 - After cutting, wait a minute for fumes to exhaust
 - Remove part, remaining stock material and all cut pieces from the laser cutter
 - Wait for the cooling fans to slow down
 - Turn off laser cutter power
 - Shut off air assist
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Safety

The glass lid of the laser cutter blocks the IR beam and interlocks disable the IR beam when the lid is opened. Laser safety glasses are not required for using the laser cutter. Shop safety glasses are recommended.

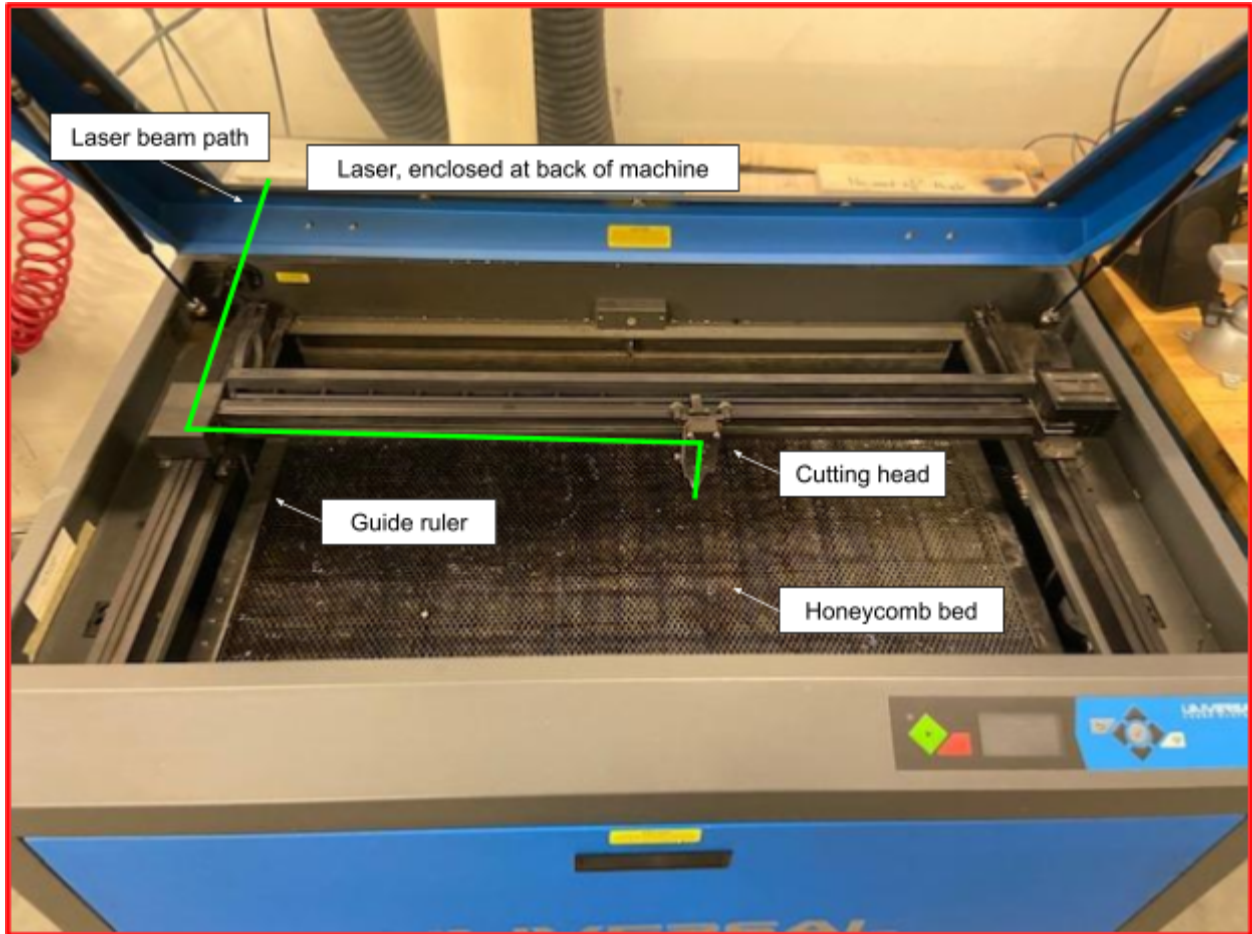
All materials will release fumes while cutting. A functional **exhaust is required for all cutting**.

Some materials release poisonous and/or corrosive gases that **should never be cut**. These include:

- PVC (or any material containing chlorine) releases chlorine gas
- Delrin releases formaldehyde
- ABS releases cyanide
- Teflon/PTFE releases fluorine gas

Introduction

Laser cutting is a fast and accurate way to produce 2 dimensional shapes from flat material. We have a Universal Laser Systems 75 Watt CO2 laser (10.6 micron wavelength). The below image shows the basic components of the laser cutter.

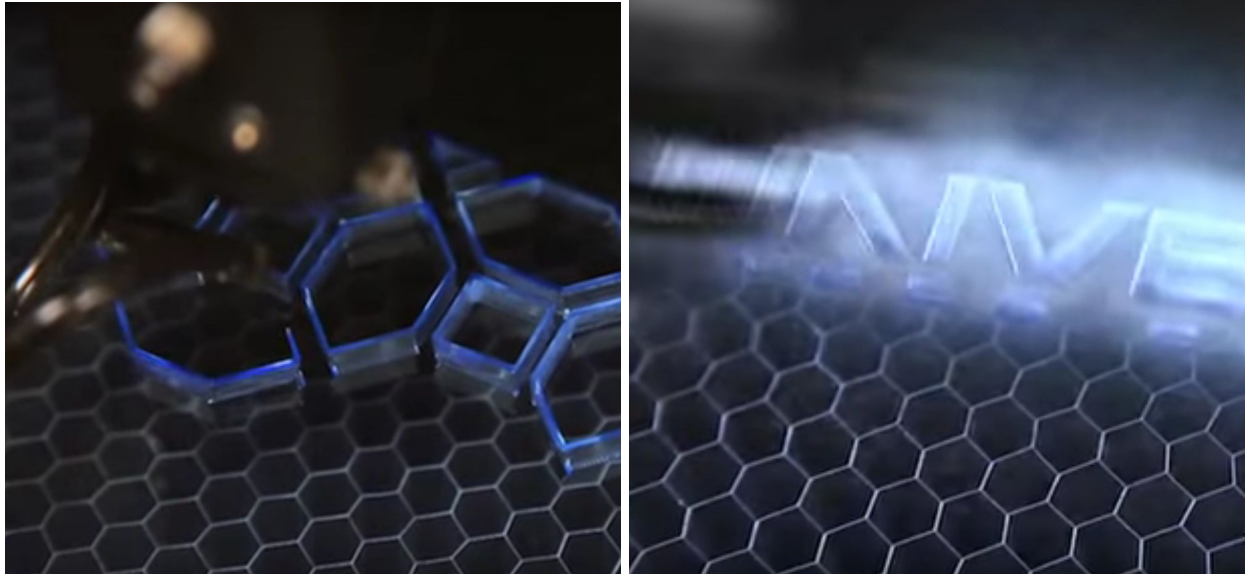


During cutting, the cutting head will move in X (left/right) and Y (towards/away from the back of the machine). The laser will be modulated during this movement to produce your part and air will be constantly blown out of the cutting head to disperse fumes that would otherwise scatter the laser and could ignite. Your part will be cut from material that rests on the honeycomb bed surface and prior to cutting the machine will raise or lower the bed to the commanded height to bring the focus of the laser onto the surface of your material.

This laser cutter is capable of cutting a variety of materials at a range of thicknesses. The most commonly cut material is ¼" acrylic (we will discuss other materials later).

The laser cutter can make 2 types of cuts:

- Vector cuts that typically pierce through the material and are produced during a movement between 2 locations
- Raster engraving that typically removes a small amount of material from the top of your stock during rapid left/right movements over an area of your design



Left above shows an example vector cutting operation on clear acrylic where the head slowly moves between points while running the laser at a high power capable of cutting completely through the material. Right above shows an example raster engraving operation on clear acrylic where the head rapidly moves left and right and the laser is pulsed at precise times to remove small amounts of material from the surface of the acrylic. The white haze is acrylic dust produced during engraving.

Our machine is optimized for vector cutting. Raster engraving will take significantly longer and is typically only used for producing small text labels on parts.

When the laser cutter is turned on and the lid is open, a red alignment laser will shine through the beam path. This red laser is useful for aligning your design and provides an indication for when the lid interlock is tripped. If you are trying to cut and instead see the red laser pointer it is likely that the lid is not fully closed.

Suitable Materials

The most commonly cut material is $\frac{1}{4}$ " acrylic. The laser cutter can cut the following materials:

- Acrylic < $\frac{1}{2}$ " thick
- Wood (typically plywood) < $\frac{1}{4}$ " thick (make sure this is not pressure treated)
- Cardboard and paper (be careful as these materials have an increased risk of fire)

If you would like to cut a material that is not listed above contact us and we can discuss your options. Designs made for the laser cutter are typically easy to transfer to the water jet. The water jet can cut through a much wider range of materials (including metals) and thicknesses (up to several inches thick).

Acrylic typically arrives with a protective film that is either plastic or paper. The plastic film can be left on during cutting. However, paper film on the top surface should be removed prior to cutting to reduce the risk of fire. If you are cutting material that does not have this protective film and you want to protect the surface of the acrylic from char marks and redeposited acrylic dust you can use the roll of adhesive plastic film located near or under the laser cutter. If you are cutting many small parts it can be helpful to remove any film prior to cutting to prevent needing to peel film off of many small parts.

Material is typically purchased from McMaster-Carr or from Altec. Our laser cutter can hold pieces up to 32 x 18 inches in size. Altec can provide sheets of this size, if purchasing from mcmaster carr 12 x 24 inches is a commonly used size that will fit in the laser cutter. Please contact us if your design will not fit as the water jet can be used to cut larger sheets (up to about 5 x 5 feet).

We do not supply or stock new material. For small designs, scrap material can be found under the center work table in the shop near the laser cutter (see the image below). **Do not use material from any other location in the shop.** For all unknown material, verify that it is acrylic (and not some other plastic) before cutting. If you are unsure, do not use it in the laser cutter.



Any leftover material that has an uncut area larger than 6 x 6 inches can be donated to the shop by placing it in the scrap material storage. If the remainder of your stock does not contain at least a 6 x 6 inch usable area please dispose of it in the trash. **Acrylic scraps are not recyclable.**

Software: Making your design

Creating a design for laser cutting can be done with any 2D vector graphics software (Illustrator, Inkscape, Corel Draw, etc) or with CAD software (AutoCAD, Solidworks, Fusion360). Covering the design process is outside the scope of this training but we are happy to help. Please contact us and we'd be happy to discuss your needs and help you find the right solution.

For all designs, you will need to load your file into Corel Draw (installed on the computer by the laser cutter) before starting your cuts. Corel Draw supports importing several file formats with the following being the most common vector formats used in laser cutting:

- DXF
- SVG
- PDF (which contain postscript, PS, vector designs)
- AI (illustrator files)

When designing your parts keep in mind that vector cuts on the laser cutter suffer from two major problems:

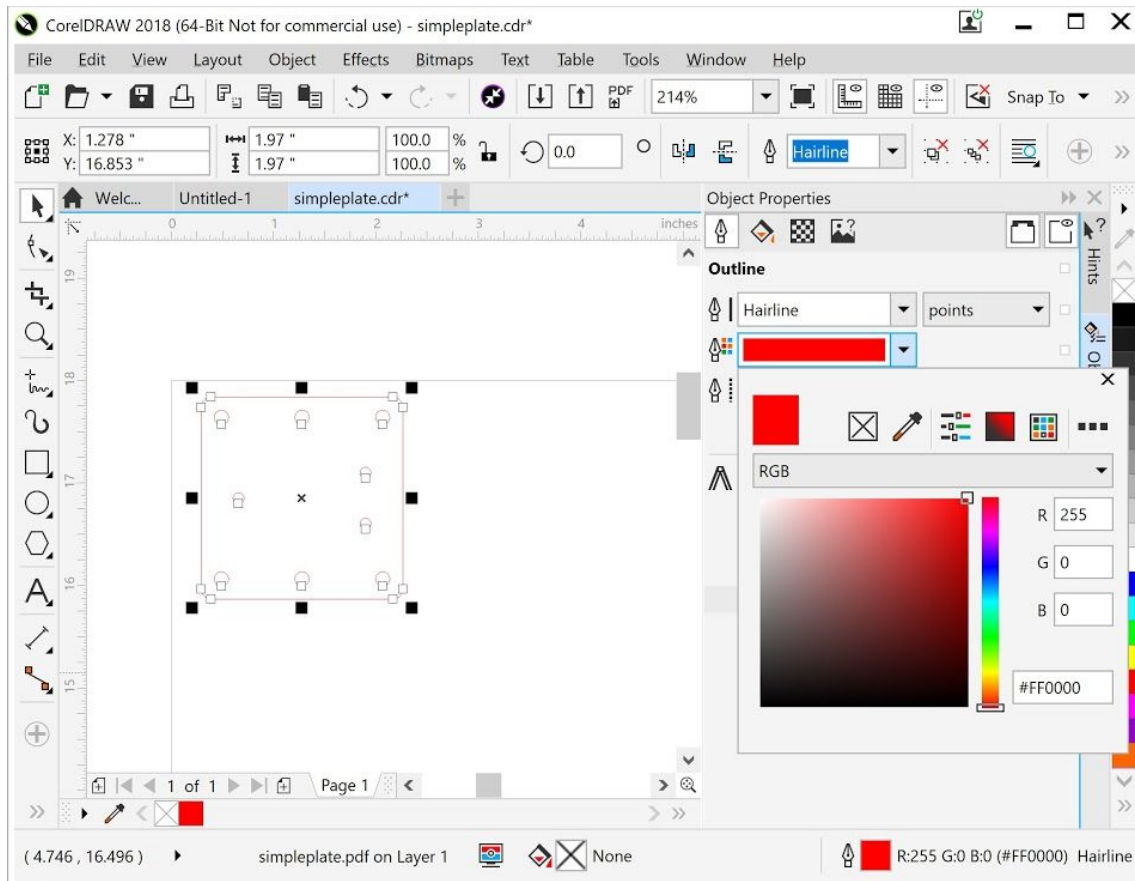
- Cut edges will be tapered and not at a perfect 90 degrees to the face of the material
- Cuts will occur ON the designed lines and the laser cutter will remove some material during cutting. The amount removed (the kerf) will depend on the material, cut settings, alignment and age of the laser. If you design a 1/2" circle the cut circle will be slightly less than 1/2" in diameter and the hole left behind will be slightly larger than 1/2" diameter.

Preparing for your cut: Corel Draw

After importing your design into Corel Draw (File -> Import) you will need to perform the following steps:

1. Verify the size of your design to check for any scaling issues
2. Adjust line thicknesses and colors to tell the laser cutter what parts of your design to cut and what parts to etch
3. Make sure your design is located on the page of the document

Below is a screenshot of Corel Draw showing a 1.97 x 1.97 inch design (shown below the Object menu).



Any lines that you want to be vector **cut** must be of "**Hairline**" thickness and be a **pure red** (with component colors RGB = 255, 0, 0).

Any features that you want to be raster **engraved** should be **black** (RGB = 0, 0, 0) and the thickness will determine what area is etched.

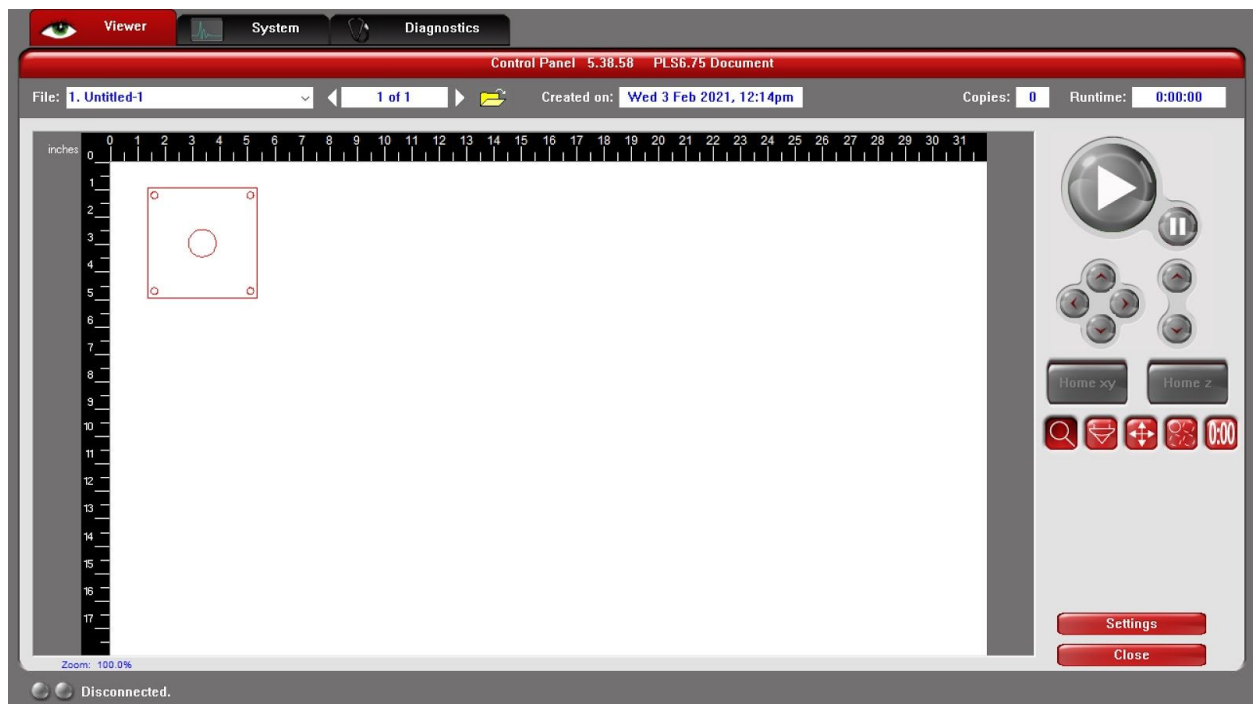
Your design must fit on the 'page' of the document (anything outside the page will be ignored). However, the position can be changed at later steps.

Once you have confirmed the scale and line properties of your design use File->Print to send your design to "PLS6.75". This will process and copy your design to the next program, Universal Laser Control Panel (UCP).

Configuring the laser: Universal Laser Control Panel (UCP)

The UCP program can be started from the start menu or may be activated from the notification area in the bottom right of the screen. Once open you should see the design you just printed from Corel Draw. If not, you may need to zoom out using the zoom tool and mouse scroll wheel.

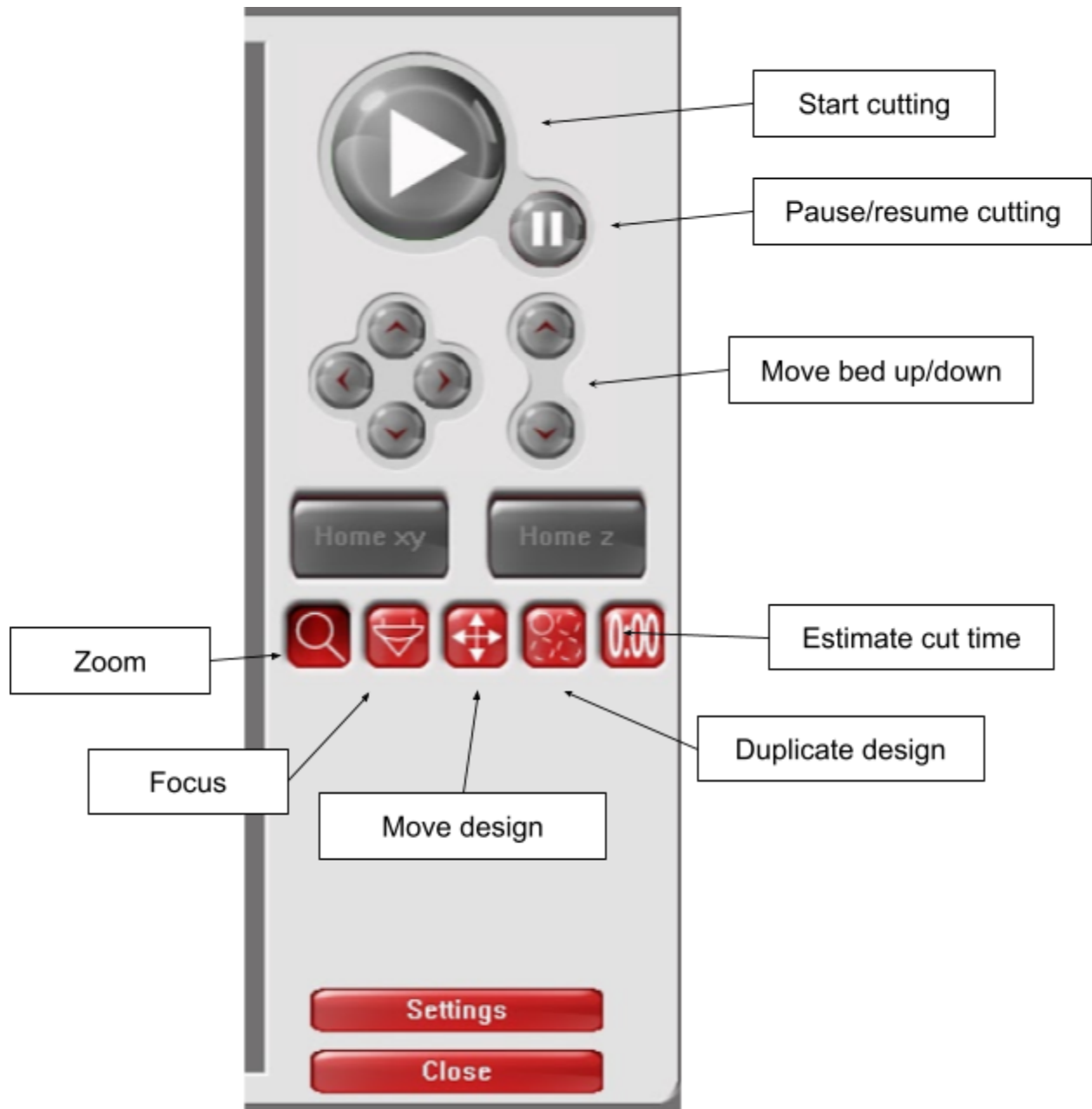
The screenshot below shows the 3 tabs (Viewer, System, Diagnostics) along the top. The large white design area and the tool area on the right hand side of the window.



The system and diagnostics tabs are beyond the scope of this training. Do not modify any settings on those tabs and instead contact us and we will be happy to help you make any necessary changes.

In the tool area (towards the right side of the window, see the diagram below for a zoomed in and labeled screenshot). You'll find buttons to start, stop, pause and resume cutting, move the honeycomb bed up and down, and 5 red tool buttons that allow you to:

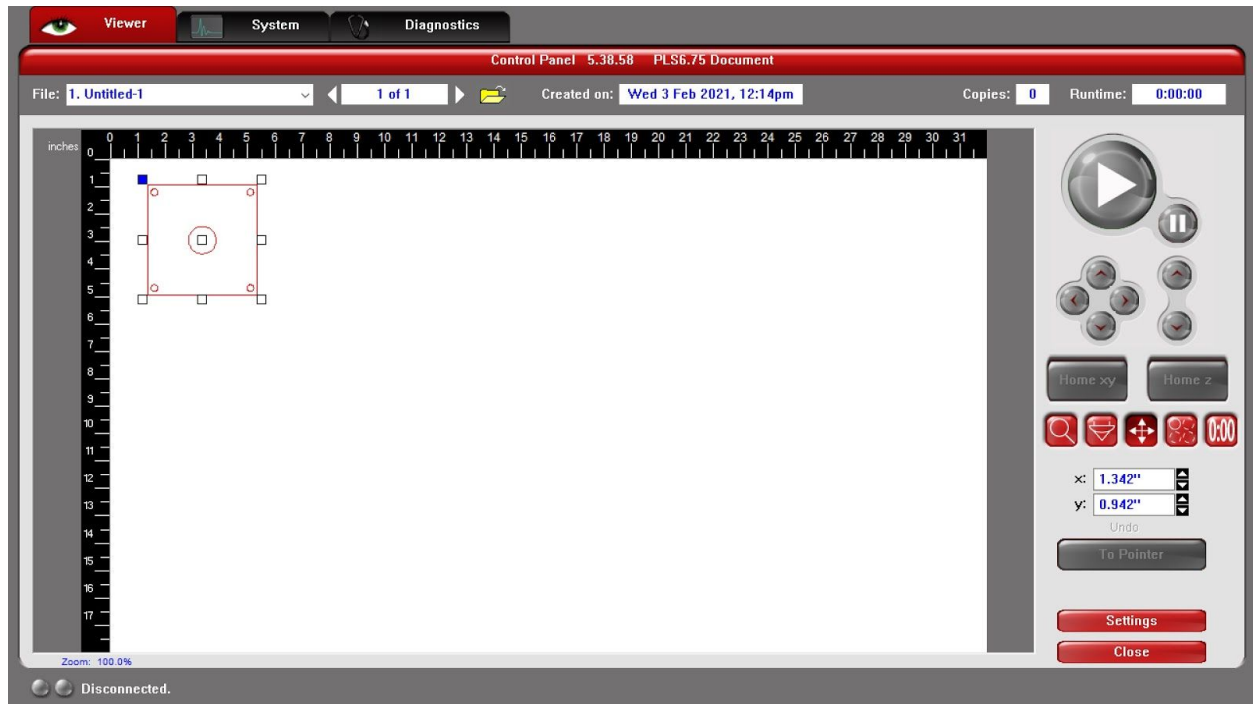
- Zoom in and out on your design (using the mouse scroll wheel after the zoom tool is selected)
- Focus the laser and quickly move the head around to align your part
- Move/relocate your design in the cutting area
- Duplicate your design for cutting multiple parts in one session
- Estimate your cut time



Relocating/moving your design

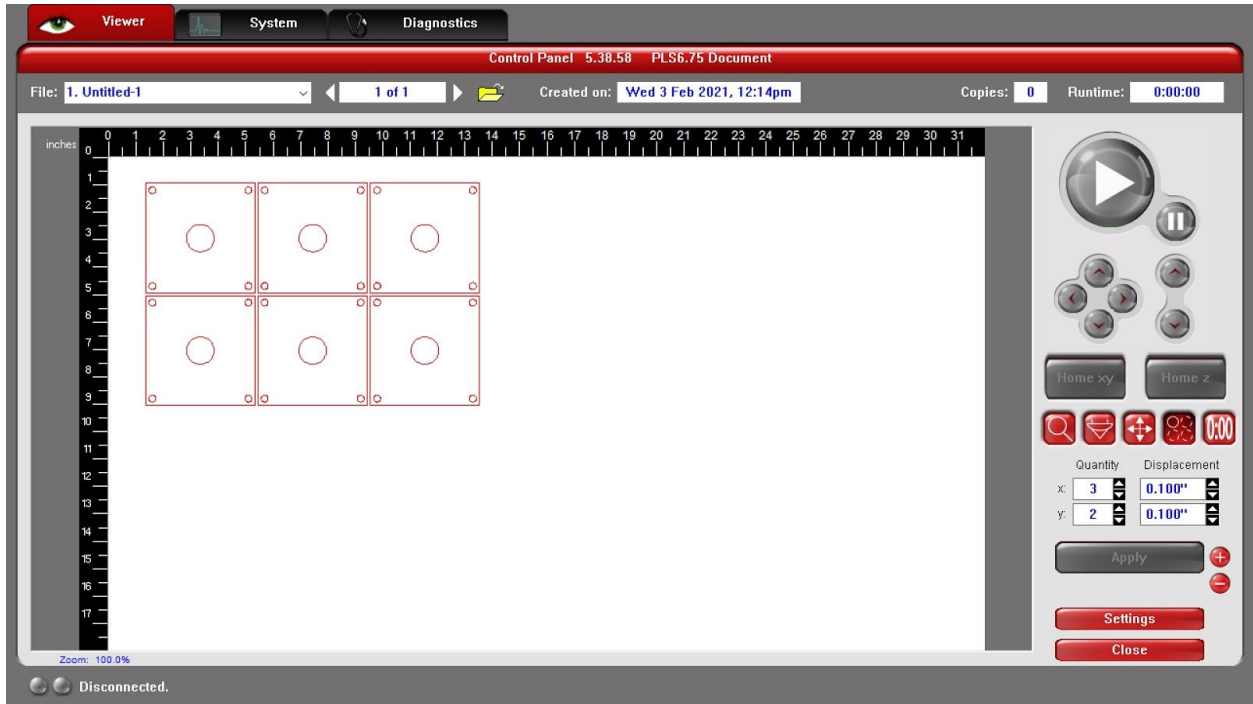
One of the more useful tools is the relocate/move tool. When active, your design will display 9 small squares (all white except for 1 blue) which act as fiducials/anchor points to help you position your design in the cutting area. When this tool is active you will also see additional numeric entries in the tool area for X and Y positions of the currently active (blue) fiducial. Clicking one of the other (white) fiducials will cause it to turn blue and become the active fiducial. Typing a value into the X or Y input then pressing Enter allows you to change the

position of the currently active fiducial. Most cutting is done towards the upper left of the cutting area with the top left fiducial located at $X = 0.2$ and $Y = 0.2$ inches. This allows you to position your stock against the top and right rulers in the machine and positions the cutting far enough from the edge of the material to reduce the risk of fire and make it unlikely that you will cut into the rulers.



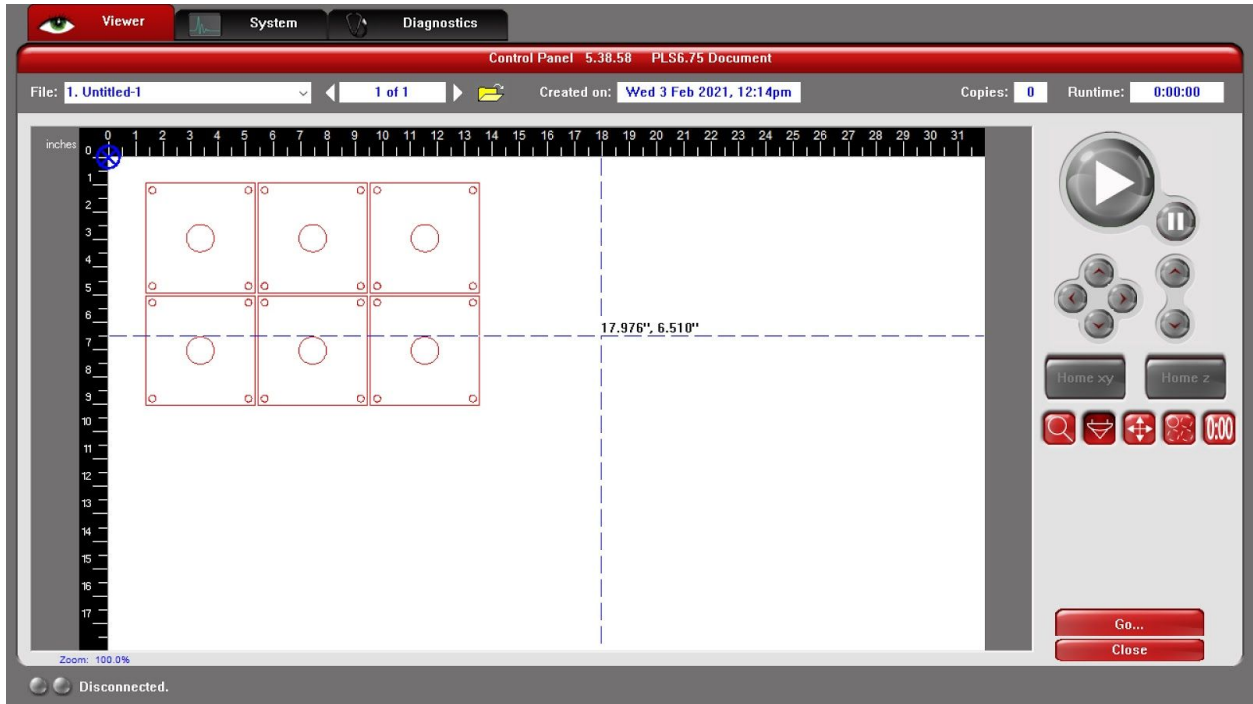
Duplicating your design

If you are cutting several of the same small part, the duplicate tool in UCP can be used to set the tiling size and spacing of your parts. Using a spacing of at least 0.1" is recommended to reduce the risk of fire and melting of your parts.

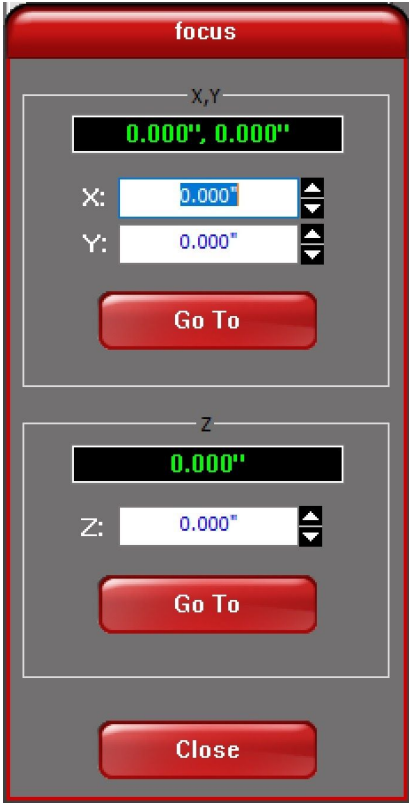


Focus/aligning your design

When the focus tool is active your mouse cursor will be tracked by a blue dashed crosshair when it is over the white design area. If you click in the design area, the cutting head of the laser cutter will rapidly move to that location inside the machine. **Always ensure the cutting head will not run into your part** or anything else before moving it with the focus tool.



Clicking the Red 'Go' at the **bottom** of the tool area allows you to move the head to an X, Y position and to move the cutting bed to a Z height.



If you are attempting to line up your design with existing features in your stock it can be useful to use the following procedure:

- Activate the focus tool, increase the Z value to increase the distance between the cutting head and your material until the value is greater than your material thickness
- Put your material in the machine
- With the lid open, move the red laser pointer to the target location using the focus tool
- When the head is at the correct location, switch to the relocate tool and use the 'To Pointer' button to move the active (blue) fiducial to the current location of the cutting head

Settings: Configuring the laser cutting parameters

Before starting any cut you must confirm your settings are correct. Clicking the 'Settings' button (visible at the bottom of the tool area, if you do not see the button, switch to the zoom tool) will open the settings dialog. This dialog contains 2 tabs:

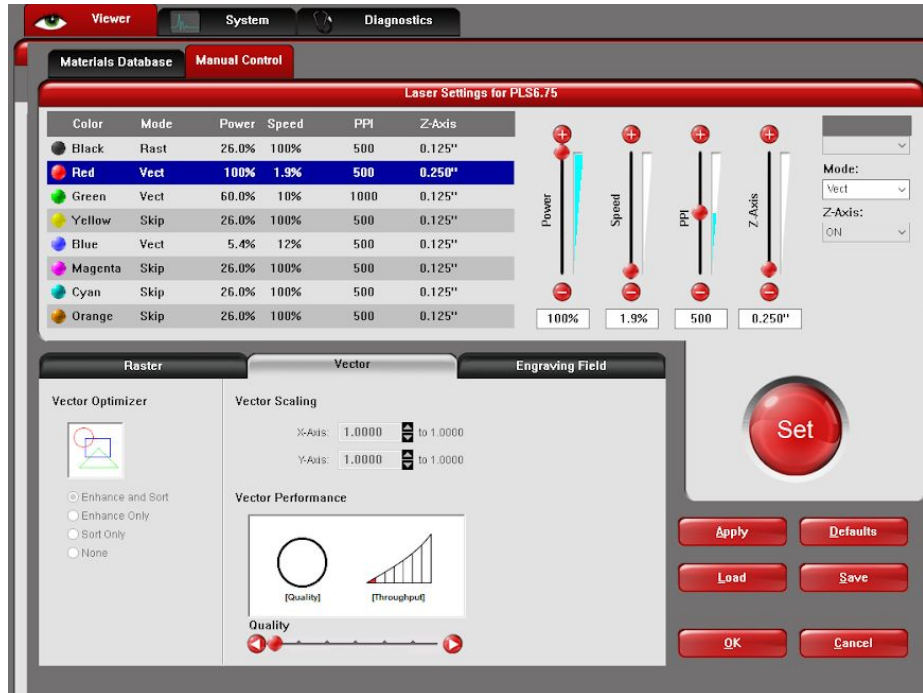
- Materials Database: A list of default settings for many materials and a good starting point
- Manual Control: More extensive control over laser power, speed, and other advanced settings

The screenshot below shows the Materials Database tab where 'Cast Acrylic' is the selected material and 0.25 inches is the selected material thickness.



When using the Materials Database there are a few settings you want to confirm:

1. Select the material in the upper left tree view. Note that many materials are listed here and not all of these are cuttable or allowed on this laser cutter. Review the 'Suitable Materials' section of this training document before selecting a material.
2. Enter the 'Material Thickness' in the dialog towards the lower left. **Do not press enter** after typing the value as this will close the dialog and not accept your settings. Instead, click the 'Apply' button near the lower right.
3. Verify that the 'Vector Performance' slider is all the way to the left for maximum 'Quality'
4. Verify that all 'Intensity Adjustment' sliders at the top right are at 0%
5. After all settings are verified, click 'Apply' then proceed to the 'Manual Control' tab to further verify your settings.



The 'Manual Control' tab contains a number of advanced settings that are mostly beyond the scope of this training. However, it is **important to verify a few items before every cut**.

The table towards the top of the dialog shows the mapping between colors and laser settings. To change any entries in this table you need to first select the row you want to change (by clicking on it to make it turn blue). Be careful because the software allows you to select multiple rows. Clicking on a selected (blue) row will deselect it. When the correct row is selected, modify the settings using the controls to the right of the table then click the circular red 'Set' button to update the row. If you do not click the 'Set' button your **changes will have no effect**.

For each color you can set:

- 'Power' from 0-100%. For all $> \frac{1}{8}$ " thick plastic this will likely be 100%
- 'Speed' from 0-100%. Most plastic will be cut at a speed $< 6\%$. Slower speeds will be used for thicker materials, faster speeds for thinner materials.
- 'PPI' (pulses per inch) from 0-1000. 500 is sufficient to cut through most materials and produce a clean (non-jagged) edge.
- 'Z-axis', this should match the thickness of the material you are cutting to put the focus of the laser at the top of your stock

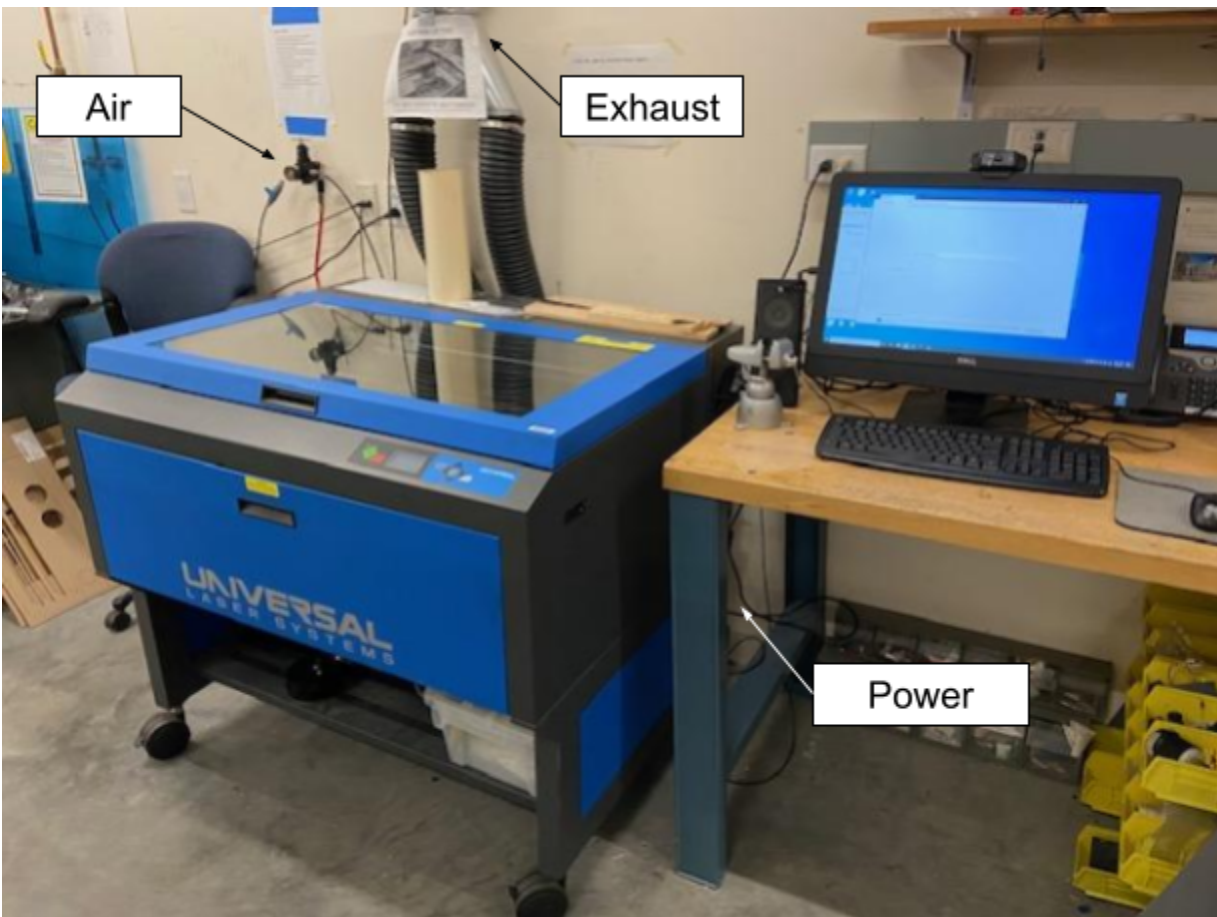
Before proceeding with cutting confirm:

- Your power and speed is suitable for this material
- Your PPI is set to 500
- Your Z-axis setting matches your material thickness

Cutting a design

When you arrive at the machine, you will need to follow a number of steps to prepare the machine for cutting. These include:

- Prepping then printing your design in Corel Draw
- Configuring your settings in UCP
- Confirming the fume exhaust is operational (do this before turning on the laser cutter)
- Turning on and confirming the air assist is working
- Powering on the laser cutter



Exhaust

Before turning on the laser cutter, open the lid of the machine and listen for the sound of the air being exhausted from the cutting area. If you do not hear this sound, confirm that the exhaust gate valve (pictured below) is in the open (out) position. This should always be open and if found closed, contact us. If you confirmed the valve is open and you do not hear the exhaust, **do not continue with cutting** and contact us immediately.



Air assist

The blue handled ball valve (pictured to the left below) is used to control the flow of compressed air into the machine. This valve should be in the closed position when the machine is not in use. To open the valve, rotate the blue handle so it is parallel to the tubing (the valve is in the closed position below). Next, confirm the regulator (centered below) reads between 15 and 45 psi. This can be adjusted using the metal tee handle on top of the regulator.



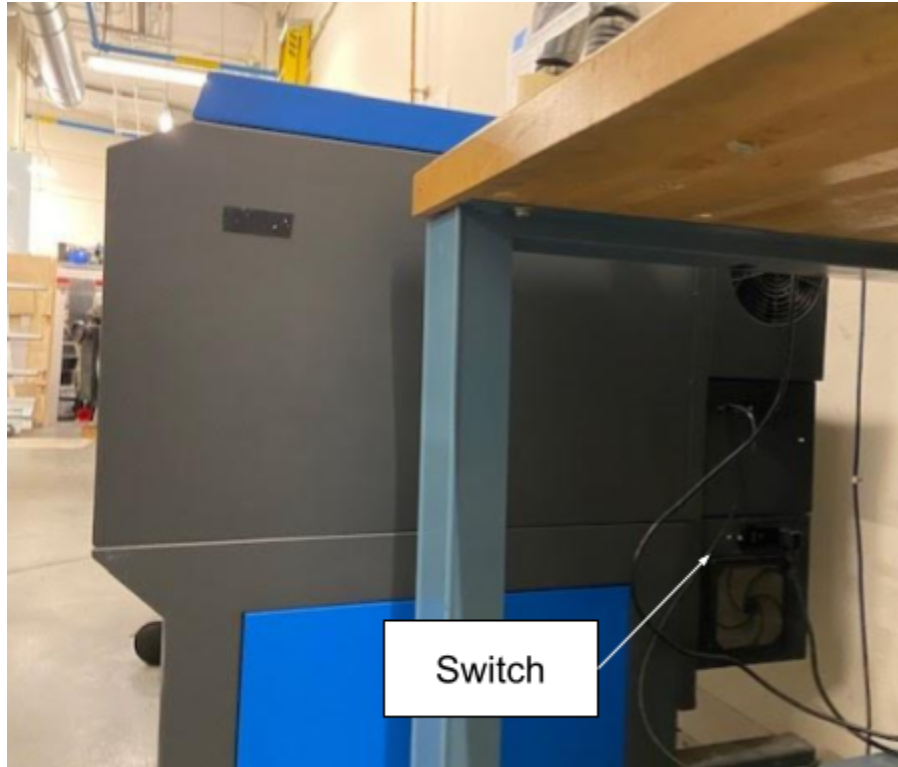
Finally, confirm that air is blowing out the nozzle of the cutting head by placing your finger near the cone at the bottom of the cutting head.



If you do not feel a steady stream of air out the hole in the bottom of the cutting head, **do not continue with cutting** and contact us immediately.

Power

The power switch is located next to the power cord of the machine.



The laser cutter will take several tens of seconds to boot up. After booting you should see a screen that looks something like the following on the display at the front of the machine and a green connected indicator at the bottom left of the UCP program.



Inserting your stock material

Lift the lid of the machine and place your material on the honeycomb bed. Be careful to not run your material into the cutting head while inserting it into the machine. If you find the head is too close to the bed you will have to go into the focus tool in UCP and increase the height.

At this time also confirm that the honeycomb bed is pressed all the way towards the back and left of the machine. The bed is not rigidly affixed to the machine and can slide away from the

guides. Use gentle pressure to slide the bed towards the back of the machine until it stops moving and repeat the process moving the bed to the left.

Check to make sure your material is sitting flat. If it rocks it is likely sitting on a small piece of plastic or warped. Do not attempt to cut warped material as it can catch on and damage the cutting head.

Final check before cutting

- Confirm that you are ready for a fire (and know the location of the air gun and fire extinguisher)
- Confirm that you will be at the laser cutting watching and attending to the entire cut
- Confirm your settings are correct
- Confirm the laser cutter has exhaust, air assist and power
- Confirm that your material is correctly placed in the machine
- Press the green start button at the top of the UCP tool area to start the cut

During the cut monitor for the start of any fires that are larger than 1 cm or persist after the head has moved away from the area. If you see a fire, pause the cutting, open the lid and extinguish the fire as described above.

After cutting finished

Wait a minute (or more if you're doing a lot of cutting) to allow the fumes inside the machine to be exhausted. Open the lid and confirm the laser cut through the expected parts of your design. Use one hand to hold onto your material and use your other hand to wiggle your cut parts, if your parts do not feel separated from your stock you can repeat the cut by closing the lid and restarting without moving your stock material.

Remove all material: your parts, any remaining stock, and any small scrap pieces from the honeycomb bed. If you are taking these parts back to an office, know that they will outgas for several hours after cutting and it's best to keep them in a well ventilated area.

Turn off the air assist by closing the blue handled valve.

Wait for the laser cutter cooling fans to slow down to a normal idle level before turning off power to the laser cutter.

Sharing the equipment

Every tool in the shop is shared equipment.

We share the building with many pieces of multi-million dollar equipment. We do not want to start a fire.

Leave the laser cutter and area cleaner than you found it.

If you find that the laser cutter isn't behaving as expected contact us immediately

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