

# Laser Cutting and Engraving Orientation Packet



**Full Spectrum**  
LASER

# Laser System Basics and Safety

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## What is a Laser System?

**Laser cutting** is a method of fabrication that uses a high-powered laser to cut or engrave a material. Modern laser systems are Computer Numerical Controlled (CNC) machines, meaning they receive a set of instructions from one or more computer programs that dictate where to cut and with how much intensity. We often refer to laser systems simply as **laser cutters**.

## Common Types of Laser Systems

- **CO2 laser cutters** pass current through a carbon dioxide mixture to produce the laser. They are the most common lasers for household “hobby” laser systems because of the wide range of materials they affect and their relative affordability. These laser systems work well with wood, acrylic, fabrics, and more, with high-powered systems handling certain light metals. *Both of our systems at PCC Cascade are CO2 systems, detailed below.*
- **Nd laser cutters**, also known as **crystal** laser systems, are industrial systems often used for boring. Nd (neodymium) and Nd:YAG (yttrium-aluminum-garnet) systems are extremely high-powered and can work effectively with metals and ceramics, but these crystals are expensive and systems suffer from a lower life expectancy than their CO2 or fiber counterparts.
- **Fiber laser cutters** are solid-state lasers, using a solid medium rather than gas or liquid. They are increasingly common among household and industrial systems because of their affordability in both upfront cost and repair, and the beam width on these systems is considerably smaller than that of the CO2 or Nd laser systems. *Check out SPI Lasers for a fiber-only laser system seller.*

## Applications of Laser Systems

- **Production:** with precise and easily repeatable steps for cutting certain materials, it is possible to mass produce small items like jewelry, coasters, puzzle pieces, and more.
- **Enclosures:** designing a simple box is as simple as making a fold-out and using wood screws or finger joints to connect the sides, and the variety of materials available for use gives the option for weather-resistant or waterproof enclosures.
- **Artistry:** traditional pencil or ink drawings can be transferred to materials like wood or acrylic with relative ease. Other techniques like papercutting can be streamlined by using the laser cutter to handle delicate or difficult cuts, or for cutting stencils from paper and cardboard.

## Safety Concerns and Best Practices

The laser cutter has the potential to become dangerous when certain rules are not followed. Note that the laser cutter must always be monitored while in use and handled with care - as such, **a STEAM Work Experience instructor must always be present for its use**. The rules below are crucial to safely utilizing the laser cutter at any time:

1	Verify that <b>ALL fire safety equipment is in place</b> before beginning any job with the laser cutter. This includes a <b>CO2 fire extinguisher</b> and <b>leather safety gloves</b> that must remain in proximity to the laser cutter at all times.
2	If a fire starts, <b>STOP the current job and ALERT the nearest instructor immediately!</b>
3	<b>NEVER leave the laser unattended while cutting</b> - most fires start when the operator walks away!
4	Ensure that the fume extractor is <b>ON</b> during operation of the laser cutter; it works to contain potentially toxic fumes. If you smell something, <b>STOP the current job and say something!</b>
5	Know what material you're working with - <b>if you are not sure what it is, do NOT attempt to cut it!</b> Some materials emit extremely toxic fumes when cut that the laser cutter / fume extractor cannot handle.

If you have any questions or concerns about the laser system at any time, including when the laser system is running a job, ensure that the system is paused or stopped and immediately reach out to an instructor.

In addition, please be sure to follow the General Safety Rules posted in the STEAM Lab and Cascade Fab Lab.

## What Materials are Safe / Unsafe to Cut or Engrave?

Some common materials used in the laser cutters include birch plywood, acrylic, cloth, paper, and cardboard. **If you are not sure what a material is or where it came from, do NOT attempt to cut or engrave it!**

For a comprehensive list of materials safe and unsafe for cutting, please visit the [PCC Fab Lab MUSE Materials Guide](#) or the [ATX Hacker Space Laser Cutter Materials](#) page.

## How Do I Prepare a File for Laser Cutting or Engraving?

This course will use three programs for the design and utilization of the laser cutter. These programs will be covered in the next pages:

- **Adobe Illustrator**, a vector drawing program
- **Retina Engrave 3.0**, “printing” software for the Muse Hobby Laser
- **ULS Print**, a “printing” application for the Universal PLS6

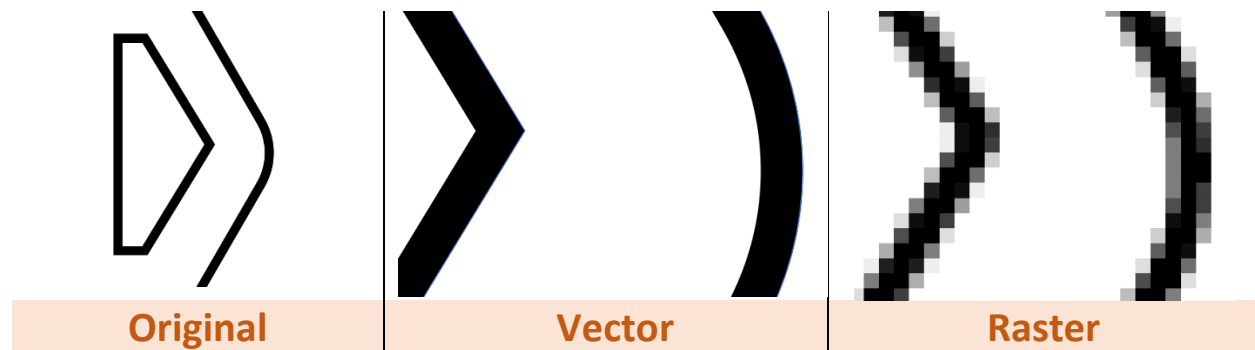
# Adobe Illustrator for Laser Cutting

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## Why Adobe Illustrator?

**Adobe Illustrator** is a *vector drawing program*, or one that uses vector math to draw paths between two or more anchor points. **Vectors** are a constantly-calculated distance between two points on a flat plane, redrawing paths as needed when the user resizes or zooms in on an object. The result is an image with no noticeable change in resolution at any size or zoom rate.

**Raster**, on the other hand, is a pixel-based image. Most computer graphics and digital photography are raster images; these must be handled differently by the laser cutter. For a closer look at the differences in a vector and raster graphic, take a look below:



We will examine how the laser cutter interprets data from these two image files in the next section.

## Getting Started

1. Go to the Start Menu and locate **Adobe Illustrator 2018** or begin typing “Adobe” in the search bar to find the program. Click to open.
2. Create a new file by going to **Create New** on the left panel, or by going to **File -> New...** in the top toolbar.
3. A new window should appear. If this window has a panel labeled **Preset Details** on the right, begin by clicking on the dropdown menu that gives a unit of measurement – select **Inches**. Set your **Width** and **Height** values to match or exceed the size of your material\*.
4. Finally, click on the **Advanced Options** arrow button and make sure that **RGB Color** is selected from the Color Mode menu.
5. Click on the blue button labeled **Create** at the bottom to continue.

*\* If you do not know your material size or the desired size of your final product, you can set Width and Height to the laser cutter’s bed size – this can always be changed later!*

## Tutorials and Online Resources

We will be doing an in-class learning activity to make a keychain. Once that is complete, you will use the following resources to advance your learning of Adobe Illustrator for laser cutting or graphic design.

1. Go to Adobe's tutorial website at <https://helpx.adobe.com/illustrator/tutorials.html>
2. Starting with the top row of videos, watch and complete the tutorials titled "Create and edit shapes," "Change color and strokes," and "Add text to your designs."
3. Take a look at the rest of the tutorials on the page above. Choose any that interest you – logos, app icons, print images, and more are designed on Adobe Illustrator. Use this time to get a feel for some of the tools available in the program. You can also watch the following video if you would like to learn more about these tools: [https://www.youtube.com/watch?v=UqjZR\\_v37K8](https://www.youtube.com/watch?v=UqjZR_v37K8)

## What You Should Know

While Adobe Illustrator is packed with features, it is a graphic design tool first – you will have to design in Adobe Illustrator with the laser cutter in mind if you want to cut or etch your graphics. Here's what to pay attention to:

- **Stroke and Fill:** Under the Properties of a given shape, you will see these two options:
  - **Stroke** is the border or outline of your shape and will be **RGB Red** for *vector cutting* or **RGB Blue** for *vector etching*.
    - Furthermore, the **Stroke Weight** must be appropriately set. This will vary depending on the laser system you are using, so be sure to check what Stroke Weight is needed before attempting to laser cut a file.
  - **Fill** is the inside color of your shape and must be **Black** to be rastered at max power.
- **Save as an SVG File:** When saving the file, make sure to select **.SVG (Scalable Vector Graphic)** from the dropdown menu. This allows us to import the SVG into programs such as RE3.
- **Outlines:** Overlapping shapes is often fine in graphic design, but it can lead to unwanted cuts or unpredictable results when neglected on a file for laser cutting. Pressing **Ctrl+Y** on your keyboard can show any overlapping lines. Then, use the **Shape Builder** tool to combine shapes or remove unnecessary paths or shapes from your design.
- **Layering:** Using the **Layers** in Adobe Illustrator can not only keep your design well-organized, but can be utilized when do multiple passes on a laser cutter to create tangible depth in your work. Begin using the **Layers** tool early on to separate your vector and raster graphics, or to easily lock down an image for freehand tracing.
- **Duplicate Shapes and Paths:** These are real trouble, and there's almost no way to spot them until it's too late. Be careful not to redraw or copy and paste paths where others already exist – one line on top of another often means something will get cut two or more times, and this can be as damaging to the laser as the material.

# Laser Cutting and Engraving

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## Which Laser Cutter Do I Use?

PCC Cascade Campus provides student access to two laser systems. While both are CO2 lasers and behave similarly with regards to the materials you can cut, access times for each laser cutter will vary – consider being trained on both if you would like to ensure that you have access when you need it.

- **Universal PLS6**
  - 60-watt CO2 laser
  - 32" x 18" bed
  - Handles up to ½" material (may require multiple passes)
  - Rotary attachment for etching round objects
  - Currently stationed at PCC Cascade Fab Lab
- **FSL Muse Hobby Laser**
  - 45-watt CO2 laser
  - 20" x 12" bed
  - Handles up to ¼" material (may require multiple passes)
  - Camera for snapshot image tracing or material placement
  - Set up on a utility cart for traveling between classrooms

## Vector and Raster Continued

The laser cutter utilizes two methods for cutting and engraving - **VECTOR** and **RASTER**.

- **Vector** follows a continuous path to cut complete shapes out of a material or etch into a material; must be a SVG (Scalable Vector Graphic) file
- **Raster** etches or "prints" an image into a material, up to 1000 dots per inch (DPI); can be an image from a JPEG, PNG, or SVG file



We use vector lines for both **vector cutting** and **vector engraving**. Vector cutting means to cut all the way through a material for creating complete shapes or text out from a larger piece of material or create holes for screws or nails without the use of other tools. Engraving means to burn into the material without creating holes or gaps - this often produces a clean outline of text or designs with a slight burn along the path.

**Rastering** engraves or etches the surface of our material with an image in much the same way a printer does - dotting the surface several hundred times per inch by turning the laser ON or OFF at a rapid pace. Raster graphics are often a picture converted to maximum contrast (black-and-white) or grayscale. Black-and-white simply creates two layers: black is etched, white is ignored. Grayscale, however, allows us to create tangible depth in our laser cut images, etching deeper where shades are darkest.

Vector jobs take less time but are limited to the width of the laser in most cases. While raster jobs take much, much longer than vector, our options for what we can draw on a material's surface are vastly greater in terms of depth and the materials available to us. **Some materials which cannot be cut by the laser *can* still be raster etched!**

## Muse Hobby Laser Settings and Software

To access the RetinaEngrave 3.0 software, make sure you have a laptop or desktop computer connected via ethernet to the laser cutter, then follow the steps below:

1. Open a web browser. Google Chrome or Mozilla Firefox are suggested.
2. In the browser's web address bar, type **169.254.36.114** – press Enter.
3. This should bring up a load screen with the RE3 logo, proceeding to the following screen:
4. While the software offers many options for editing your image or design, we will only be discussing the buttons in this row:



5. From left-to-right, these are:
  - a. **Capture Workspace or Clear Workspace:** Take a picture of the laser cutter bed; best for placing your design on a small or oddly-shaped surface, such as a basswood round
  - b. **Trace Image:** Use the onboard camera to take a picture of any images inside the laser cutter and vectorize it – produces interesting results with hand-drawn art
  - c. **Job Estimate:** Gives an estimated time of completion for running the job.
  - d. **Run Perimeter:** Outlines the full surface area of the job currently on the screen.
  - e. **Run Job:** Start the current job.
6. To import a file from Adobe Illustrator, go to **File -> Place...** and select the file from the Explorer window. **NOTE!** This program occasionally imports SVG files from Adobe Illustrator at ¾ scale. You will want to open Adobe Illustrator to verify that the size of your work is correct before continuing.

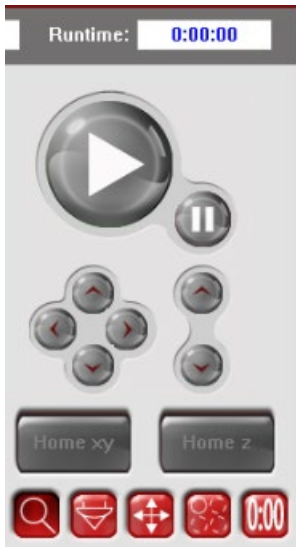
## Universal PLS6 Settings and Software

Many laser cutters come with print drivers to send the file straight from your chosen vector program to the right software.

1. With your Adobe Illustrator file open, click **File -> Print...** or press **Ctrl+P** on your keyboard to print.
2. Then, click on this icon on the bottom toolbar to open the program:



3. Once you've opened the program, you can access the **Materials Database** or **Manual Control** to begin adjusting the settings for your selected material.
4. After selecting a material preset or adjusting manual settings, press **Load** and then **OK** to continue.
5. The following menu can be used to **navigate** (arrows, Home XY/Z buttons), **focus laser**, and **start, stop, or pause the job**.





# Laser Cutting and Engraving Training Worksheet

Fill in this sheet and return when complete. This will fulfill your training.

1. Are there any terms in the document that you are unfamiliar with? Please list at least 3 and ask the instructor to define them. Record the responses here.

2. Answer the following questions:

- What type of laser is used by our two laser systems? \_\_\_\_\_
- List three materials that are SAFE to cut:
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
- List three materials that are **NOT SAFE** to cut and **why**:
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
- Specify three differences between the two laser cutters on campus:
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
- What kind of line is used to cut through a material? \_\_\_\_\_

3. Complete the following tasks:

- Laser cut and etch a keychain with the course website and your name
- Turn on each laser system and prepare a material to be cut
- Run a test on a material and log the results along with your settings
- Successfully cut your own design on to a 3x3 coaster or a keychain you designed