

# Universal Laser Tutorial

## WARNING

*The laser cutter is a potentially dangerous machine. It is very easy to start fires with the laser cutter; Stanford apparently lost part of a building to an unsupervised machine. The laser cutter can also produce dangerous fumes (e.g., chlorine) if used with improper materials.*

*Operators must receive training prior to use of the laser cutter. The cutter must also remain under constant supervision while in use. This document is very partial, and does not constitute training. Please contact the [Student Shop Manager](#) for further information.*

### **Particular warnings:**

**Never cut PVC**, or other chlorinated plastics (**Lexan** and PC board are also not to be cut). PVC in particular will give off chlorine gas, which is not only highly corrosive to the machine, but also danger for any nearby people, pets, etc. Do not engrave reflective surfaces.

**Never** cut polycarbonate (**Lexan**)! This material will create a 'flame up' situation and can crack the lens if left unchecked. If you are unaware of the material you are cutting, do not hesitate to double check with the supplier.

Constant machine supervision is a must and will not be circumvented. While most of the problems previously experienced have been eradicated, the machine is potentially dangerous and could cause any number of mishaps from fire to personal internal damage.

### **General Capability**

Our machine utilizes a 45 watt, air cooled, sealed CO<sub>2</sub> laser to cut up to ¼" acrylic, wood, paper, and foam core, among other materials. It can also etch **vector** (line/arc) and perform **raster** (image) engravings into these materials. There are **NO** CO<sub>2</sub> lasers capable of cutting any metal. Metal may only be etched if bought from the laser machine's manufacturer for such uses. At this time this will not be allowed till our research can prove that we can do this safely and efficiently.

Varied cutting speeds, power levels, and pulses per inch (PPI) allow some modulation of etching, making some limited forms of three dimensional relief possible. However, the laser cutter is primarily a 2D cutting and etching tool, with the third dimension achievable through stacking or assembly of multiple laser-cut elements or layers. If a third rotary axis is purchased by an engineering group the laser can cut round parts.

### **Responsibility**

The laser cutter is intended expressly for individual or engineering group use by the students and faculty of The Pratt School of Engineering, Duke University. Under no circumstances are outside personnel allowed to operate or run projects on the laser.

The [Student Shop Manager](#) has the **final say in all** matters regarding the use of the machine.

### **Protocol**

There is only one laser cutter and there are a lot of students. In order for this to all work, it is imperative that everyone observe some simple common courtesies. To facilitate efficient operations, it is highly recommended that you drop by the student shop in advance of your session for a preliminary review of your drawing setup, material requirements, etc.

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Inadequate preparation could cause you to forfeit valuable plot time and or your reserved time on the laser. There are no five minute jobs, so allow plenty of time for completion. The laser machine is specially equipped with an external exhaust system. It is mandatory that it be used anytime you are operating the laser. It helps with the extraction of smoke and other gasses that are produced during the operation of the laser.

[The Laser](#) is available on a first come/first served basis during normal operating hours. Any deviation from this schedule will be posted in the student shop. Illness or other personal matters may require the shop to be closed without prior notice. Please do not wait until the last minute to find out about the availability of the laser please look on [the laser calendar](#) that is on DCal or our website <http://studentshop.pratt.duke.edu/>

On any given day, it is your responsible for being in the Student Shop no less than 10 minutes before the beginning of your DCal reserved time. If you do not show up to use the Universal Laser during the time you reserved your badge will be punched. It is your responsibility to contact [the Student Shop Manager](#) to arrange a time for using the laser.

The Universal Laser must be kept clean all the time. Please pick up knockouts from your work and remember to remove your scrap when finished. Also remember it is you job to clean the machine the last twenty minutes of you reserved time. If you leave the machine in an unacceptable condition your badge will be punched.

## **Software**

Printing to the laser cutter is currently done through several different programs available: AutoCAD Inventor, Coral Draw4, Autodesk Mechanical, Microsoft Office 2003, and Paint software's are installed on the machine. It is up to each student to make these preparations in advance of using the laser. To maximize everyone's efforts, it is required that you drop by the Student Shop in advance of your reserved time for a preliminary review of your drawings for the laser.

## **DRAWING PREPARATION AND TRANSFER**

### **Basic Instructions for Setting Up Layers**

Regardless of the program in which your drawings were created, how the information is arranged will greatly affect the ease of converting to laser-ready work.

Carefully evaluate your drawing for layers. The laser cutter will likely interpret layers of lines rendered on top of one another as through-cut lines rather than as separately etched lines. Be sure to close any background layers that are incidental to the final plot. This will reduce the risk of faulty plotting.

The laser cutter currently addresses drawings in five layers, defined by one of five colors. Each color is assigned to a series of predetermined values:

- **Red** defines through perimeter cutting.
- **Cyan** is also used to define non-perimeter through cutting. (see Order of Cuts)
- **Magenta** defines the deepest intended etching. (40% speed).
- **Blue** defines medium depth etching. (60% speed).
- White defines shallowest etching. (80% speed).
- **Yellow** defines text. (100% speed).
- **Orange** is used to define construction lines which do not plot.

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The following items are general information regarding all drafting programs. For more specific information, scroll down to the program you are using. For AutoCAD, the file may be saved simply as a .dwg or .dxf.

## Drawing Setup:

Using your existing drawings:

1. Complete your drawings as required to fully explain the project. Floor plans, elevations, etc should include as much detail as necessary. Be sure to pay attention to the scale of the model, as 1:30 models will show much less detail than a 1/8<sup>th</sup> scale model.
2. Create at least 2 new layers for **CUT** and **SCORE** (etch) lines. Cut lines will pass completely through the material. Score lines will only etch the surface. The depth of the etching will be determined by the material's density and the power versus speed ratio supplied by the machine. Any lines that you wish to "plot" to the laser must be on one of these two layers, unless you inform the student shop manager of the layers you wish to use. Be sure to arrange the lines accordingly. While you may draw with different colors, the layer will determine how the laser cutter treats the lines. One line on the wrong layer can ruin an entire plot.
3. **TRACE** your existing drawing to complete the parts needed to assemble the model. Make sure your line width is set to **0.125** for CorelDraw and **0** for AutoCAD (default). Do **NOT** copy and paste objects onto the new layers. This process can create overlapping lines that will result in a poor product and unpredictable results. Also, do **NOT** use groups or attach these new objects in any way. Polylines may be used; however, they cannot contain a fill pattern except in the instances of *HATCH* patterns.
4. **CUT** lines must have a distance equal to or greater than .03". Lines closer than this will result in excessive material loss and will create a void rather than a solid. The general rule for the distance between cuts lines is ½ the thickness of the material. However, pay close attention when using acrylic as it will sometimes melt and disfigure even when following this rule. If you need specific help, contact the student shop manager for instruction. **SCORE** lines closer than .01" will typically be realized in most materials as a single, thick line. Practice is the key and will result in better results.
5. Turn off all layers that do not contain objects that will be laser cut. Copy the pieces to the clipboard and paste into a new drawing.
6. If you have changed the scale of the objects or the scale of the drawing at any time during your design work, be sure to remedy this before proceeding. If you have questions regarding changing scale, please ask the student shop manager.
7. Save the new drawing as a DXF file type. Filenames must be saved as [your drawing name].dxf. Do not include any other periods as Windows will not recognize the drawing as the proper file type and will not open the file.
8. All drawings must either be placed on a CD or on a thumb drive.

Starting a new drawing:

1. Create at least 2 new layers for **CUT** and **SCORE** (etch) lines. Cut lines will pass completely through the material. Score lines will only etch the surface. The depth of the etching will be determined by the material's density and the power versus speed ratio supplied by the machine. Any lines that you wish to "plot" to the laser must be on one of these two layers, unless you inform the Student Shop Manager the layers you wish to use. Be sure to arrange the lines accordingly. While you may draw with different colors, the layer will determine how the laser cutter treats the lines. One line on the wrong layer can ruin an entire plot.
2. Create the necessary lines to complete the pieces you wish to have cut and scored by the laser cutter. **CUT** lines must have a distance equal to or greater than .03". Lines closer than this will result in excessive material loss and will create a void rather than a solid. The general rule for distance between cuts lines is ½ the thickness of the material.

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However, pay close attention when using acrylic as it will sometimes melt and disfigure even when following this rule. **SCORE** lines closer than .01" will typically be realized in most materials as a single, thick line. Practice is the key and will result in better results.

3. If you have changed the scale of the objects or the scale of the drawing at any time during your design work, be sure to remedy this before proceeding. If you have questions regarding changing scale, please ask the Student Shop Manager.
4. Save the new drawing as a DXF file type. Filenames must be saved as [your drawing name].dxf. Do not include any other periods as Windows will not recognize the drawing as the proper file type and will not open the file.
5. All drawings must be either on a CD or on a thumb drive which then can be downloaded to the Laser computer.

## Topographic Models

1. Topographies should be arranged by individual elevation. (Every contour should be separated from the one above and below it.)
2. Place the contours in a grid formation, verifying that the pieces will fit within the 31.7" x 17.7" limits.
3. Each contour should be placed on the same layer.
4. Be aware that topographies require more time than other files to plot and can result in others not being able to use the machine. Check the Laser calendar that is on DCal to make sure a scheduled time can be arranged also talk to the student shop manager ahead of time to get approval for long run projects. Others will be allowed precedence over these types of models unless prior arrangements are made and approved ahead of operation time.

Upon completion of any drawing, be sure to save it to a **Thumb Drive**, for transferring it to the Laser Computer. If these criteria are not met, the student shop manager will be obliged to send you back for further preparation.

## Materials

The laser cutter has a capacity of 32" x 18" with roughly a .125" margin on all sides. When you are creating drawings, please consider using 31.7" x 17.7" as your maximum layout space on the laser. The following is a list of materials that are commonly used in architectural model making. Other materials can be used. However, it is recommended that you contact the student shop manager before purchasing any material to insure that it is suitable for cutting.

Wood (up to ¼" thick)

- basswood, cherry, mahogany, poplar, pine, etc.

Acrylic (up to ¼" thick)

- Acrylite and Lucite are two brand names commonly available.

Paper

- chipboard, Canson, poster board, blotter paper, watercolor papers, mat board, illustration board, museum board, corrugated cardboard, foam core.

Plastic

- styrene, vinyl

Others

- tempered masonite (1/8" thick), plywood (1/8" thick), leather, cloth

There are 2 materials that will **NEVER** be allowed in the laser cutter.

Polycarbonate (**LEXAN**) and PVC based plastics create intense *toxic* fumes that can hazardous to the user and will damage the machine's rubber parts. Polycarbonate is sold next to acrylic at Home

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Depot and Lowe's. To determine what material you are purchasing, remove the masking and look at the edge. If it is clear to **green**, it is acrylic.

**Purple** and **blue** edges will always represent polycarbonate.

## **Stock**

The laser cutter stock inventories at other institution that we have seen are the following most popular sizes/types modelers routinely need. We are **NOT** currently stocking any 32" x 18" sheets of single (.045") and double ply (.090") chipboard. Clear Acrylite is available at LOWE'S in 18" x 32" tiles in .060", .125", and .250" thicknesses. In addition, we have found .030"- .500" acrylic and white styrene are sold at Golden Rule (Plastic distributor out of Haw River, NC). It can be cut also in 18" x 32" tiles.

We strongly encourage people to do early cutting runs in corrugated cardboard. It's cheap, structurally robust (for medium sized pieces), easy to mark on with a pen and hack with a knife, and environmentally sound. Note that when laser-cut, corrugated cardboard is quite sharp. Recycled material is o.k. but must be flat. **We are not stocking pre-sized corrugated cardboard at this time.**

Many other nice laser-cuttable materials do exist. We just do not stock any material. As we continue to develop our knowledge of these basic materials and increase our confidence with the machine, we will increase our database of laser technology.

**Until further notice, all materials must be bought well in advance before using the laser.** Please remove your scrap or unused materials upon the completion of your job. You may leave the large scrap pieces for future small projects but please take all small scrap with you or throw them away.

If you choose to purchase acrylic other than, that which is available at Lowe's or Home Depot call Golden Rule or Piedmont Plastics. Their prices are somewhat higher than most and there is often a one day delay for pick-up or delivery to allow for cutting when buying less than a full sheet. **G.E. Polymer Shapes**, (ph. 704.643.9006) is located at 10000 Industrial Drive in Pineville, NC. G.E. Polymer's prices are consistently lower, though their sheet materials have a less protective clear film cover.

There are two types of acrylic available cast, and extruded. Cast turns **white** or frosted and extruded remains **clear** when engraved. Use extruded acrylic for paint-filled engraving and cast for regular engraving. When only cutting acrylic, extruded works better and is less expensive than cast.

The cut edges of extruded acrylic will appear to be more highly polished and clearer than cast acrylic when laser cut.

Note that acrylic, cardboard, and wood are all readily flammable (especially acrylic and cardboard). Acrylic also gives off noxious fumes.

**And again, PVC (which occurs in many forms, including a foamed form) and some other materials are highly toxic.**

In short, if you are unsure of the material at all, **ask!** If you notice **strange green gasses**, etc. coming from your cut, **shut off the laser cutter immediately!** Do not continue cutting without first seeking advice from more experienced personnel.

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Be sure to let acrylic cuts sit for at least 30 seconds on the laser cutter bed before opening the door to the laser, if heavy etching or cutting has been done, (especially of thick acrylic <1/4") let it sit for greater than two minutes.

## **Wisdom**

This section includes suggestions and tips for successful laser based modeling. They are in no particular order, though all are important. We will continue to expand this area as we learn.

- Do not expect to through-cut styrene as it will burn excessively. Instead, use existing presets and "snap" parts clean.
- Avoid acutely angled edges on 1/4" acrylic as they are both hazardous/hurtful and likely to break. An alternative is to sand the "points" after they have been cut out.
- Cast acrylic engraves better without masking. If deep engraving is desired, it is necessary to mask the acrylic with transfer tape (available from Piedmont Plastics as *Graphix* self-adhering masking) to prevent the smoke from damaging the clear surface of the acrylic. However, another problem with deep acrylic engraving is that the intense heat creates a white, crusty, deposit that accumulates along the edges of the area that was just engraved and is impossible to remove without causing damage. Engraving lightly and without masking seems to be the better all around alternative. Also, extensive engraving concentrates enough heat in one area to cause acrylics to warp.
- Drawing, saving, re-loading, purchasing materials, setting up the drawing, and cutting normally takes a great deal more time than anticipated. Be prepared for a wait as more students understand and experience the laser cutter and what it can do.
- You get what you give. The laser cutter has a precision of 0.002" repeatability. Your output depends completely on your input. If your drawings are sloppy, your parts will reflect it. Be sure to delete any overlapping lines and use snaps when tracing existing drawings.
- Pay close attention to your scale at the beginning of the project. What you see on the monitor may not be what you get. If in doubt, print a couple of versions at varying scales to determine the amount of detail needed to represent your project the best. Scaling object from 1"=1" to 1"=8' can be done by either dividing or multiplying your measurement by 96 (8x12).
- THE LASER CUTTER IS A TOOL. Just like the table saw or the disc sander, the laser cutter has its positive and negative attributes. It is not always the best solution for a given problem. Large topographic models should be handled with a Cut-all.
- Acrylic is not always the best solution to the problem. New materials require a certain amount of experience to gain even a basic understanding of assembly and use. Unless you have a range of saws, sanders, glues, and paints, acrylic models sometimes require much more preparation and diligence than paper models.
- Zap-A-Gap and SoBo have very different qualities and can produce horrible results if used improperly. Weld-On III will not work with paper. Test your materials.
- SMALL PARTS. With certain materials (chipboard & paper), small parts less than 2 square inches will likely be blown around the machine. The most effective way to prevent this is to create small tabs on each piece to hold them in place. To create a tab, draw a circle with a diameter of 0.03" (use this formula: 0.03" x scale factor). Copy this circle to at least 2 points on each object and trim out the line inside the circle. Drawing these circles on a separate layer will allow you to avoid erasing them later. You will be able to just turn off the layer that contains them. The same results can be produced using 2 lines offset 0.03" as well.

## **End of Tutorial**