

# University of Illinois - School of Art + Design

## 3-Dimensional Output Laboratory

### Universal Laser Cutter X-660

## Guides and Help Sheets

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# Art+Design 3-D Output Lab - Procedures, Policies and Guidelines

School of Art+Design provides educational resources consisting of laboratories, classrooms, presentation rooms, studios and equipment. Room 311 Art and Design Building is the 3-Dimensional Output Laboratory. The lab has a *Stratasys Dimension SST* three-dimensional (FDM with ABS plastic) printer and a *Universal Laser Systems X-660* cutter.

## Entering and Using the 3-Dimensional Output Laboratory

**THE 3-D OUTPUT LAB AND EQUIPMENT ARE AVAILABLE ONLY TO STUDENTS WITH VALID COMPUTER LAB PRIVILEGES FOR THE CURRENT SEMESTER.**

**You are required to present your *i-Card* each time you want to use resources.** Your university student account will be charged for resources and materials used in the lab.

**YOU MAY NOT USE ANOTHER PERSON'S ACCOUNT AND YOU CANNOT AUTHORIZE ANYONE TO USE YOUR *i-Card* OR ACCOUNT PRIVILEGES.**

Access is on a "first to come is first to be served" basis. It is sometimes difficult to gauge how long each project will take to complete, so plan your 3-D output projects well in advance. Software to communicate with and drive 3-D Output Lab devices is available in the computer labs. Guides and templates are available through links on the School's website.

**3-D Output Lab resources operate through consultation with a lab assistant. The lab assistant will setup and execute your project on the equipment.**

**Only the student who is currently consulting with the lab assistant is allowed to enter the equipment area beyond the help desk.**

The lab assistant can only help one person at a time. **When many students want to use the lab at the same time, they are required to remain outside of room 311.**

**Students will not be allowed into the equipment area until it is her or his turn for a consultation.**

**Users will not be allowed to sit at the 3-D Output Lab workstations to make time-consuming changes - allowing minor adjustments will be at the discretion of the assistant.**

**On the laser cutter, you will be required to act as the "safety" observer for the duration of your use to allow the assistant to be available for consultation and other tasks.**

**You cannot drop off files and materials and leave the lab - you will be required to remain with your project for the entire time it takes to execute.**

**Use a PC Windows-formatted USB key or other external media for transporting data from your workstation to the 3-D Output Lab.**

On 3-D Output Lab workstations, **YOU WILL NOT BE ALLOWED TO LOG INTO PERSONAL SERVER DIRECTORIES OR EMAIL ACCOUNTS** to download files for use in the lab.

**Activities within the labs and use of Art+Design resources are restricted to educational pursuits and class work only.**

**Only approved materials can be laser cut. Plastics must have original identifying label.** Please note that there is no equipment in the 3-D Output Lab to cut down materials.

**The lab assistant will determine whether or not a material and method is appropriate to be tried.** There is a limited supply of approved laser materials for sale.

If you want to try something not on the approved list: first, you must consult with staff, supply material and allow five business days for testing before it can be determined if you may proceed.

Watch for special alerts that could affect your use of equipment or resources.

During times when resources are in high demand (to accommodate as many people as possible), **it may become necessary to group requests together before printing or cutting.**

**Lab assistants cannot extend open hours.** If the assistant thinks your project will take longer than the open hours remaining that day, you may be required to return at a later date.

**The School of Art+Design cannot be held responsible for lost time or the unavailability of malfunctioning equipment or services.**

**Use of the 3-D Output Lab is solely at the user's risk. Failed results cannot be reimbursed in any manner, including but not limited to:**

**time charges, variances in material causes unexpected results or user supplied material is ruined because of an improper setup or execution by the lab assistant.**

This means that when using lab equipment, the School will not replace or reimburse you for a failed cutting session or an improperly modeled print that fails.

**Credit for equipment use time or lab supplied materials will be at the discretion of Art+Design Staff - lab assistants cannot issue credit.**

**The lab assistant will place materials and prints into equipment (like laser bed or print bath). Please ask for permission before using any lab equipment, tools or tables.**

**There is no storage area available for materials or projects. Completed laser jobs or items remaining in the lab will be placed in or near the Lost&Found (locker 3214)**

**3D print jobs that are not picked up within two weeks of completion will be discarded.**

**FOOD AND DRINKS ARE NOT ALLOWED in the 3-D Output Lab at any time by anyone.**

**Cell phones should not be used in the labs, please turn off ringtones and take all your calls outside of the laboratory to avoid disturbing others.**

**Activities within the Art+Design Building are monitored for your security and safety and are subject to video surveillance.**

Lab personnel will answer your technical questions to the best of his or her ability or may refer you to your instructor, a staff member or other informational resources, but

**the School of Art+Design, staff and assistants cannot be held responsible for the consequences or the outcome of suggested solutions to questions or problems.**

If you encounter a problem, have other concerns or special needs, please consult first with your instructor or a lab assistant for possible solutions.

**You can use the online Art+Design Forums to report problems and to submit feedback < [www-s.art.uiuc.edu/labs/forum/](http://www-s.art.uiuc.edu/labs/forum/)>**

**Failure to comply with any policy may result in the loss of your privileges.**

# Quick Start Guide for Using Art + Design's Laser Cutter

Start your project by consulting with a 3D Output Lab Assistant for advice about the best way to plan your project. The laser system can't cut everything. Examples of materials that cannot be attempted are metal, glass, and stone. You are required to read and comply with the *Art+Design 3D Output Lab Procedures, Policies and Guidelines*.

Use the Adobe Illustrator laser cutter template file ( "AdobelaserTemplate.ait" ) that is available on the School's website. This template file has the correct laser color swatches and is formatted to the necessary 32"x 32" Document Size.

The template also has a separate layer for each color and if used, can help you more easily correct problem objects.

**Plan for 1/4 inch margins of unused material for all laser projects. To prevent warping, plan with the smallest size possible.**

The cutter bed is 18" tall by 32" wide, but the laser cannot cut materials all the way to the edge of the bed.

Your Illustrator document's "lasering" area cannot exceed 17.75" tall by 31.75" wide.

Your file's colors "tell" the laser cutter what to do. Also, an object's "thickness" or width is another laser controlling factor.

Colors that the laser understands are broken down into three "driver" settings: Power + Speed + Laser Pulses per inch.

Width values and thicknesses "tell" the laser cutter that the object is either a "Raster" or "Vector" command.

There are four very specific colors that interface and "drive" the laser cutter in this order:

**Black Raster objects etch first; followed by Green Raster etches;**

**then Blue Vector engraving happens and Cyan Vector elements are cut last.**

**Black** is designated as the **Raster Shallow "Shape" Etch** color and removes a small amount of material from the surface.

**Green** is the **Raster Deep "Shape" Etch** color and removes more material from the surface than the shallow etch.

**Blue** is designated as the **Vector Line Engraving** color AND is useful for making rapid "score" and surface marks.

**Cyan** is the **Vector Line Cutting** color and the laser beam will cut all the way through the material sheet.

**Talk to a lab assistant about using colors to control how the laser cutter proceeds with your file.**

Photo images "Placed" in your Illustrator file are treated as varying levels of gray and interpreted as Black Etches.

**Solidly filled objects, shapes, thick lines and text are always treated as Raster Etches,**

but can be made to etch "shallow" by using "Black" or the same object will etch deeper with a "Green" "Fill".

**Raster etching takes a long time,** because the lens must move incrementally back and forth to remove material from the surface.

Blue Vector Engraving and Cyan Vector Cutting commands generally take less time than etching.

**However, there is a significant difference in the total time it takes the laser cutter to complete the same file**

**on thin paper than on thick plastic because thick materials generally require slower speeds and more power.**

The four basic Red-Blue-Green (RGB) colors Art + Design 3D Output Lab currently uses to "drive" laser functions are:

**Black R=0, G=0, B=0 for Raster Shallow Area Etch (and all "photo" images);**

**Green R=0, B=0, G=255 for Raster Deep Area Etch;**

**Blue R=0, B=255, G=0 for Vector Line Engrave;**

**Cyan R=0, B=255, G=255 for Vector Line Cut.**

Colors must conform to these specific RGB colors or the laser cutter will produce unwanted results.

All Vector cutting and engraving line weights should be .0001 inch "Stroke" width maximum with **NO "Fill"**.

Thicker Stroke weights may be interpreted as "raster" etch objects rather than "vector" cut lines.

**Important: "white" or color fills will cause errors when trying to vector cut.**

**General Rule - due to the "warp" factor (inherent to unstable materials like wood, cellulose-based boards and some plastics): cutting many small sheets produces better results than cutting everything from one large sheet.**

## Laser Cutting Light Weight Materials at the 3D Output Lab

Laser cutting light weight materials like paper, film, cloth and leather is difficult because the exhaust system pulls so strongly it lifts the material from the bed. The bad results include: sheet moves from the original position while it is being cut; partially cut but attached pieces strike the moving lens carriage ( bad for lens ); pieces cut free during the process get pulled into the exhaust; sheet won't stay flat during process and with some media, there is a 'flapping' action that causes changes in the focus point as the sheet moves up and down.

In addition to badly cut files, small pieces get sucked into the exhaust system. Which is a danger of possible fire caused by smoldering media ( especially paper or cloth ) after being pulled into the pipeline and ignited by the oxygen forced upon it. **This fire danger is an important reason why all jobs MUST be watched during the ENTIRE laser process, so someone will see pieces flying off the project as they are sucked into the vacuum system.**

**General recommendation for planning a project is "small and many."** As materials are heated and cool during the process, they warp and this will cause inaccuracies ( or failures ) in the final results ( especially seen in large sheets with many cuts and/or etches ). Because of warping, cutting many small boards with a few items is preferable to one large board with many cuts or etches to be made. In other words, better results are obtained by using the smallest sheet size possible and using multiple files as necessary to get the number of pieces needed for the project.

Examples of light weight material includes: laser and inkjet papers; card stock, film, charcoal, drawing and watercolor papers, fabrics and leather. Consult first with a lab assistant before deciding which method is best for your project. **The final decision about whether or not your chosen method and material is acceptable to be attempted will be completely at the discretion of the assistant in charge of the 3D Output Lab.**

### Secure Sheet

**LIGHT WEIGHT MATERIALS MUST USE SOME METHOD TO KEEP THE SHEET FLAT AND SECURE ON THE BED AND THE FILE MUST BE MADE SO CUT PIECES WON'T COME LOOSE OR STRIKE THE LENS CARRIAGE AS IT MOVES ABOVE THE PROJECT.** The lab will use an adhesive putty to secure your project to the cutting bed, **but there is NOTHING THAT WILL KEEP A WARPED BOARD FLAT!**

**You will not be allowed to use non-approved materials ( objects, metal, stone ) as "weights" to hold down materials, because of the potential for damage to the system.**

Tape is useful for holding the many cut pieces of finished jobs while they are still on the bed as a complete sheet. When the completed sheet is lifted, everything will stay in place for transport and pieces can be easily identified later. **YOU MUST SUPPLY TAPE FOR POST-PRODUCTION SAVING AND TRANSPORT OF COMPLETED PROJECTS.**

## AN APPROPRIATE METHOD OF CUTTING LIGHT WEIGHT MATERIAL MUST BE CHOSEN:

- 1) **LAYERED** - material placed between two heavier boards, produces inconsistent results and surface can NOT be etched or engraved;
- 2) **GLUED** - material adhered to heavy board, can be etched and engraved, but requires extra steps and possible material stretching during gluing process;
- 3) **BROKEN LINES** - REQUIRES file using vector line breaks, material is held by a pre-made template or other approved fastening method.

## LIGHTWEIGHT MATERIALS WILL NOT BE ALLOWED TO BE CUT, UNTIL ALL CRITERIA FOR SECURING ARE MET:

(1) ALL MATERIALS ARE SECURED FLAT TO CUTTING BED;

**AND** (2a) MATERIAL IS 'LAYERED' BETWEEN HEAVY BOARDS;

**OR** (2b) MATERIAL IS 'GLUED' TO BOARD;

**OR** (2c) FILE WILL 'BROKEN LINE' CUT WITH A TEMPLATE OR OTHER APPROVED METHOD AND PIECES WILL REMAIN ATTACHED TO THE ORIGINAL SHEET SECURED TO THE BED.

**Caution:** FIRST consult with a lab assistant regarding which compositions CANNOT be used like PVC-based cloth, vinyl leather and upholstery fabric.

### Layered Method

Place a light weight sheet between two pieces of flat, ( NOT WARPED ) mat or chip board. You will be cutting through the top board, through the desired material sheet and lightly into the bottom board ( but not through bottom board ). This procedure holds the 'middle' light weight sheet in place, but sacrifices the two boards. Layering works especially well for saving small pieces that have vector lines that are not properly "broken" when created ( see "broken line method" ) and the small pieces are kept in place by the weight of the top board and are caught by the bottom board as they are freed from the material sheet.

A problem with the layering or 'sandwich' method is getting consistent results when cutting through multiple sheets of whatever materials you bring as 'heavy' boards. Also, layering will NOT allow 'etching' or 'engraving' elements on the surface of the light weight sheet. The lab assistant will have to do some experiments in advance of attempting your project and it's a good idea to bring extra sheets and boards with you.

### Glued Method

Gluing is a good procedure to use for flexible materials ( fabric, leather ) and **it allows you to etch and engrave the surface**. It helps to begin the process by flattening the material using a hot iron. In some cases, it may be desirable to stiffen the material with water-soluble spray starch. The starch helps keep the material from stretching and deforming before the next step: gluing to a board. If you don't stiffen the material before gluing, then material that is stretched during the gluing process will return to its original shape after laser cutting, leaving the project deformed and out of shape.

Attach the stiffened and flattened material to some sort of appropriate, stiff, cheap substrate like heavy weight, chip board for support during the cutting process. "UHU" brand glue stick or "YES" brand school paste work well, because both adhesives are acid free and remain water-soluble after the glue dries. Do NOT use glues that can't be dissolved in water. Do not choose water-based glue labeled 'permanent' because it contains PVA ( Poly Vinyl Acetate ), which starts out water soluble, but turns into plastic when dry ( like latex or acrylic paints ) and will not dissolve later.

Apply a thin layer of glue to the board ( if 'YES' paste is chosen, use an adhesive trowel that has little grooves in it to keep the glue thickness uniform as you pull across the surface of the board ). Then carefully apply the material from one end of the board to the other ( without trapping air between the material and the board ). Allow material and board to dry flat and under pressure ( between sheets of glass with weight on top ) before attempting to laser cut.

When the project is done laser cutting, submerge and soak the entire board in a sink until the material floats freely from the board. Then discard the boards and thoroughly wash the starch and glue from the material and set aside to dry on a flat surface ( glass works well ).

**Remember to plan on the smallest possible size sheets to prevent warping!** Have your board(s) and planned method ready before you come to the lab. *[Note: you will NOT be allowed to do any of the gluing, mounting, soaking or washing processes in the 3D Output Lab.]*

The downside of the glued process is the many steps, extra tools and wet material that later must be dried and flattened. Drying can lead to shrinkage and distortion of the end product, especially with leather. A positive aspect of 'gluing' allows you to etch and engrave the material surface.

A quicker and easier method uses spray adhesive ( rubber cement ) and if done correctly, only a small amount of adhesive residue should stick to the finished light weight material. Apply a VERY light coating of spray adhesive to the board and allow the glue to set to tackiness. Then carefully roll the material onto the board without trapping air bubbles or stretching ( pre-stiffening material helps ). The adhesive spray should be light enough to grab the material, but not so heavy as to 'glue' it to the board. The material can then be lifted from the board after cutting ( solvent may be necessary if glue adheres to the material ).

**Important for all glued and mounted projects:** in addition to the mounted material, a small sample piece of the material should NOT be mounted, so the lab assistant has something to measure for thickness and the appropriate laser cutter setting to be applied.

## Broken Vector Lines Method

**"Line breaking"** means making tiny interruptions in a ( normally continuous ) vector line to keep the pieces from being completely cut from the original sheet. When the job is done, you can use a sharp blade to cut the purposefully attached pieces from the original sheet. Loose pieces pose a significant danger to the laser system when they are free to be pulled into the exhaust or allowed to strike the lens passing above.

To prevent damage to the equipment from loose pieces that are pulled toward the vacuuming exhaust: you are **REQUIRED** to create files for light weight materials using the “broken line” method, because there is always a chance that pieces will “fly” away during the process. For example: a rectangle will need at least four “breaks” to prevent it from being pulled away from the original.

In addition to “breaking vector lines”, the remaining sheet must be completely secured to the bed by adhesive putty or a template before you will be allowed to proceed.

*Note: refer to “Making Line Breaks for the Laser Cutter” later in this guide that shows you the basic Illustrator Tools to get started in properly preparing your files.*

## Using Templates to Secure Material

There is a physical template available ( made of quarter-inch acrylic ) that holds down only the edges of Letter-sized, light weight materials while they are being cut. Coordinating with the template: there is a pre-made Illustrator File Template titled “LhtWtLetterTemplate.ait” available on the School’s website that locates the usable area boundaries ( that is 1/16” smaller than each side of Letter size ) for a material sheet that is 8.5x11 inches.

**Important: using templates requires the you to create a file using the ‘broken line’ method ( small gaps in the continuous vector line ) to prevent pieces from being pulled into the exhaust system or striking the lens after pieces are cut from the original sheet.**

On the software side: “Copy and Paste” your file elements within the template’s usable rectangle. **THE “BROKEN LINE” METHOD MUST BE USED WITH TEMPLATES: BE CERTAIN NO PIECES WILL DETACH DURING THE PROCESS that could cause damage to the laser cutter or the exhaust system. Also make sure that none of your laser elements are outside the template’s boundary box ( or the laser will cut into the template and ruin it ).**

You can create custom acrylic templates for specific purposes, but the the material the template is made of must fall within approved materials criteria and won’t damage anything if accidentally struck by the laser. The “template” can’t be made of metal, stone or objects that could ‘bounce back’ the laser beam, move during the process or interfere with device movement.

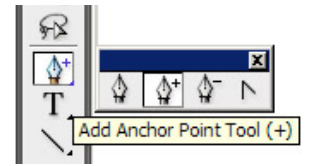
## Exhaust Air Choke

An air flow controller or “choke” is part of the exhaust system. The lab assistant may choose to lessen the air flow to help complete a project successfully in coordination with one or more of the methods described above. This is entirely at the discretion of the assistant consulting on your project. Light weight material cutting projects will only be allowed to proceed when all safety criteria are met with best practices.

# Making Line Breaks for the Laser Cutter

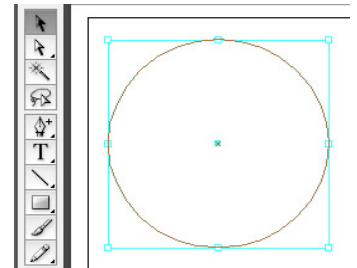
*“Line breaking” means making tiny interruptions in a ( normally continuous ) line to keep the pieces from being completely cut from the original sheet. For example - a rectangle will need at least four “breaks”: one for each side. Making files with interrupted lines will prevent potential damage to the laser cutter when using thin materials.*

- 1) You are going to use the **Add Anchor Point Tool** to create two new anchor points on a line. Then you will delete the small segment in between the anchors to create a break. You can easily identify paths and anchors by turning on **Smart Guides** in the **View** menu. You may want to “Zoom In” on your object to precisely control the next steps. Turn off all “Snap to ...” commands in **View** menus to help create very small, precise breaks.



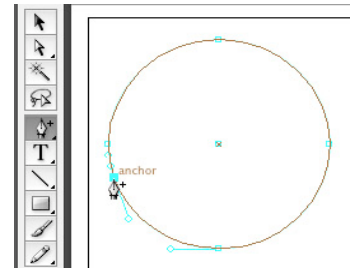
**Step 2**  
select object

- 2) With the Illustrator **Selection Tool**, choose the shape or object that you want to modify.



**Step 3**  
place first anchor

- 3) Then select the **Add Anchor Point Tool** and place the first anchor point along the path.



**Step 4**  
place second anchor

- 4) Place a second anchor point on the same line path, approximately 1/32th of an inch away from the first anchor.  
*Note: 1/32" is the minimum line break width needed to keep objects attached to the original sheet material. To assist with estimating 1/32" line breaks, go to Preferences, Grid menu and change the Vertical and Horizontal Document Grids into a Gridline Every 1 inch with 32 Subdivisions.*



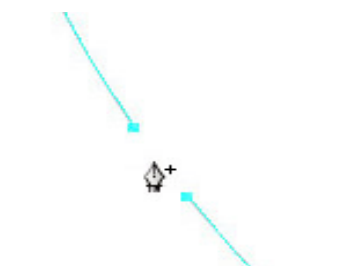
**Step 5**  
select line segment

- 5) Select the line segment “path” in between the two anchors.



**Step 6**  
delete segment

- 6) Press the **Delete** key to remove the segment and create the vector line break. Repeat Steps 2 through 6 as needed for your file to prevent equipment damage when cutting light weight or thin material sheets. After “lasering”, you can use a razor or Xacto blade to carefully cut the “line breaks” and remove the objects from your sheet.





# How to Make Text Stencils with the Laser Cutter

*The following instructions show you how to create laser cut "stencils" from typefaces and text fonts using Illustrator. However, if you choose a light weight material, you must also use one of the methods described in this guide to prevent fires and to protect the laser cutter system from damage.*

- 1) You are going to use the **Text Tool** to create your type and you'll turn the font into outlines as vector graphics. Next you will place tiny rectangles to span and connect letters with inside cutouts like letters: a, B, d, O, g, etc.. You will subtract the rectangle shapes using **Pathfinder**. You will then change all the stroke and weight values to the proper settings to "drive" the laser cutter. **IMPORTANT:** If you choose a material that is considered light weight, you must use an approved method.

Depending upon your choice of typeface, fonts smaller than 24 to 36 point become difficult to reliably stencil cut. You may want to "Zoom In" on your object to easily control the next steps.

Turn off all "Snap to ..." commands in **View** menus, so you can precisely place your connectors on the text.

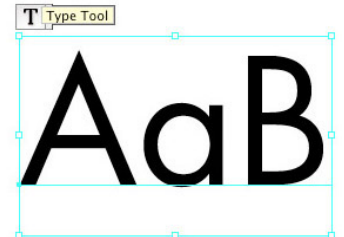
1/16 of an inch is about the minimum stencil width that will withstand the laser without breaking or burning up.

Go to **Preferences, Grid** menu and change the **Vertical** and **Horizontal Document Grids**

into a **Gridline Every 1 inch** with **16 Subdivisions** to assist you with making proper width rectangles to span the letters.

- 2) Use the Illustrator **Type Tool** to create the text you want to turn into a stencil.

Step 2  
create text



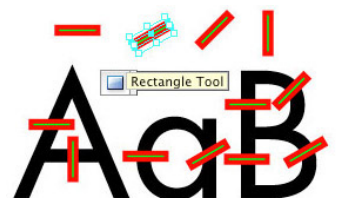
- 3) With the text selected, go to **Create Outlines** in the **Type** menu.

Step 3  
create vector outlines



- 4) Select the Illustrator **Rectangle Tool** and create a set of connectors or "spanners" to speed up the stenciling process and to help give your project a consistent look throughout the text.

Step 4  
make "spanner" set  
and place on text



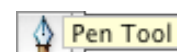
In the example, the four basic spanners were created from the first one.

It was copied, pasted and rotated at 30°, 60° and 90° to make a set of four connectors.

You can then copy, paste and place a basic rectangle to connect inner portions of letters that need "stenciling".

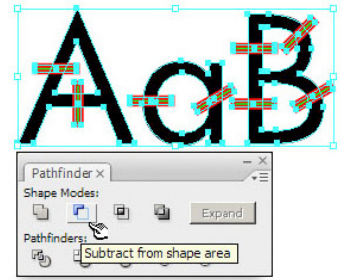
You can create as many different kinds of spanners that you feel are necessary for your project.

You can also use the **Pen Tool** to make "freehand" spanners and spanner sets.



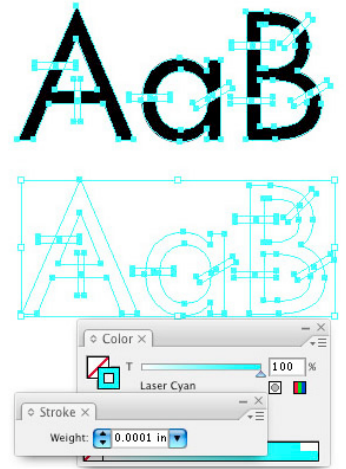
- 5) Go to the **Window** menu and make the **Pathfinder** menu visible. Make certain that the outlined text and all spanners are selected. Click on **Subtract from shape area** button in the **Shape Modes** menu.

**Step 5**  
using Pathfinder  
to subtract spanners



- 6) Be sure all text and spanners are still selected. Change all **Stroke Colors** to "Laser Cyan" [ R=0, B=255, G=255 ] with **NO FILL**. Change all **Stroke Weights** to **.0001 inch** ( or point size unit ).

**Step 6**  
change stroke weight  
and color values



- 7) Your text should now look something like the example to the left > [ note: example is shown in a bolder stroke weight for clarity ]

**Step 7**  
finished stencil



**IMPORTANT:** If you are using material that is considered light weight, you must choose to have your project laser cut using the "layered" method or you must now continue by creating "line breaks" on this file.

Approved methods are described in detail in this guide at:  
"Laser Cutting Light Weight Materials at the 3D Output Lab" and  
"Making Line Breaks for the Laser Cutter".

To protect the equipment and to prevent fires, an approved method for cutting light weight materials must be applied before your project will be allowed to be attempted in the lab.

Consult in advance with the 3D Output Lab Assistant for guidance about the best way to plan your specific project.