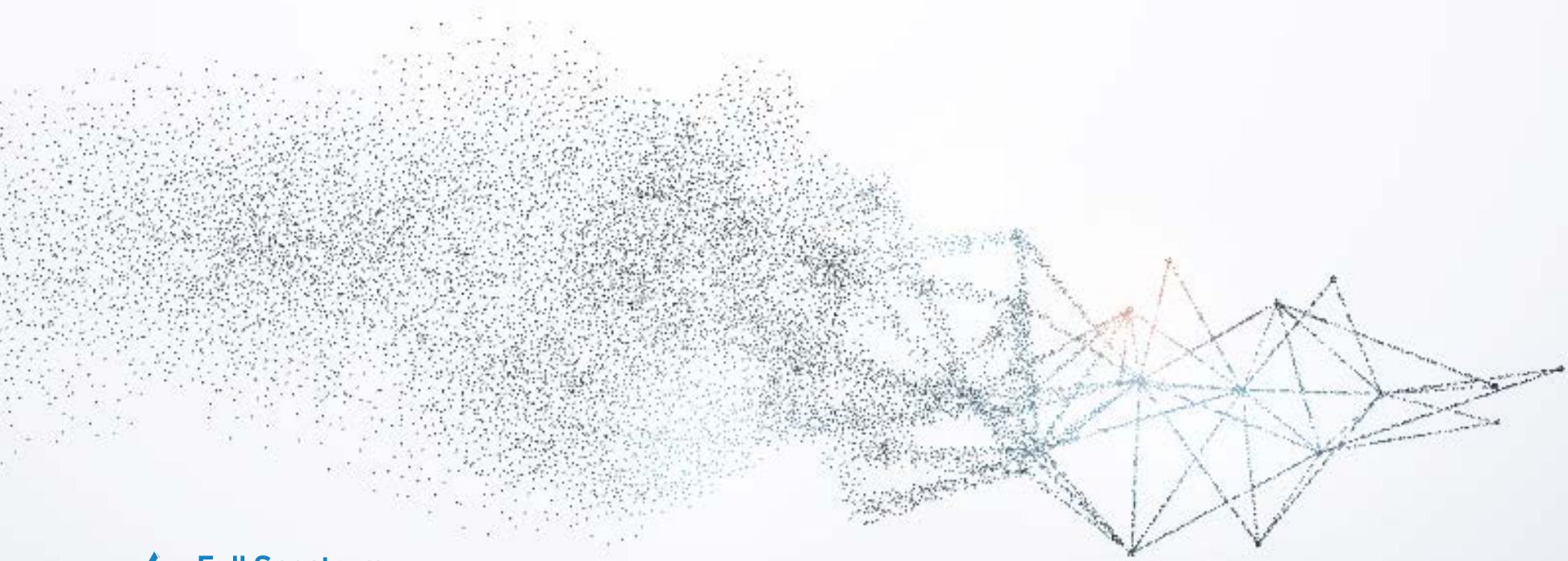


# DESIGNING FOR LASER CUTTING

A Technical Ebook for Creatives



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# WELCOME

Laser cutting and engraving are skills anyone can learn. What separates the amateur from the expert, however, is the accumulation of techniques that enhance the final results of a project. This ebook will give new users professional design tips to achieve the best results possible with a laser cutter. From simple vector cuts to complex rasters, readers will discover a host of useful techniques to give the highest level of success with each project, as well as tips to save time and money.



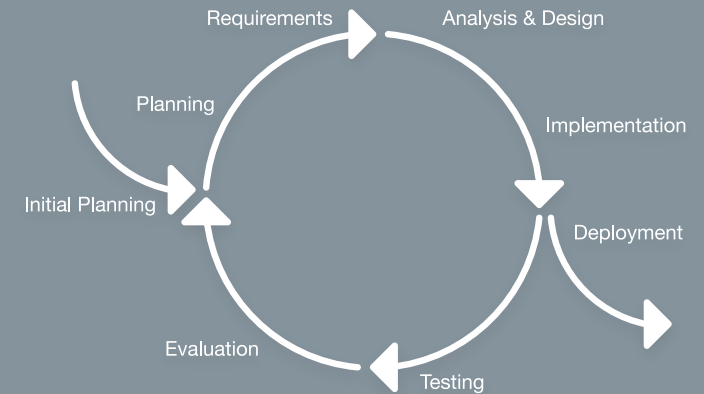
## *Note:*

*This ebook assumes laser operators have some experience using their laser cutters. These techniques are not step by step project instructions, but rather cut to the chase on discussing methodologies you can add to your already developing skills. Operators should be familiar with all safety protocol. If you are looking to learn basic operations of your laser cutter, go to the "Additional Resources" section at the end of this ebook for guidance.*

# 1 DESIGN BASICS

## Prototyping & Iterations

The real advantage of laser cutters utilizing digital designs is that their technology can create near perfect replication of projects. For designers, this means they can experiment with their prototypes with small, incremental changes. This is called the iterative design process and allows a project to “evolve” step by step until the best version is discovered. It also allows for a great variety of designs based off a core concept.



## Design Software

Many of the techniques described in this ebook will start with creating a concept in design software. While you can find many projects that just give you the design files, to get the most out of your laser cutter, you will want to learn to create designs yourself using design software. For this ebook, we will be using a variety of design software for different techniques. In most cases, this software is either free or there are free alternatives.



## PDF Files

PDF files have great versatility and are easy to use. Because they contain both vector and pixel information, they work for just about any project. Most design software can save a file as PDF or have a print to PDF function. Although RetinaEngrave 2.0's print driver can send many different file types, PDFs are preferred due to their inherent qualities of retaining resolution.



## Hardware

These projects were created using laser cutters by Full Spectrum Laser with RetinaEngrave 2.0 software. That being the case, other hobby lasers will be similar in form and function, as far as settings and basic operations.



# VECTOR

## Project Examples

Signs, Logos, Parts, Gears

## File Types

EPS, PDF, SVG

## Preferred File Type For RE 2.0

PDF

## File Composition

Geometric Formulas

## PRO Software

Illustrator /  
Corel Draw

## Free Alternative

Inkscape



# FILE TYPES

When designing a laser cutting project in software, we will want to know what kind of project we will be creating and its associated file types.

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There are three basic functions of a laser cutter: vector cutting, raster engraving and jobs that are some combination of the two. Knowing the difference will greatly increase an operator's understanding of what they are trying to accomplish in any given design.

# RASTER

## Project Examples

Image Engraving, Surface Marking

## File Types

JPEG, GIF, PNG, TIF, BITMAPS

## Preferred File Type For RE 2.0

JPEG

## File Composition

Pixels

## Free Alternative

Gimp

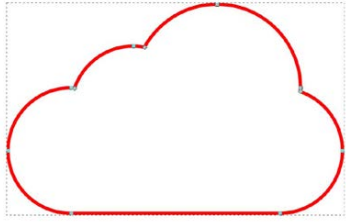
## PRO Software

Photoshop /  
Corel Draw



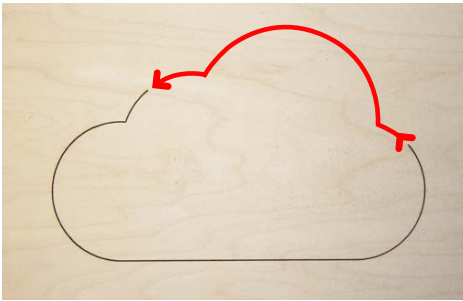


## V E C T O R S



### Vector Images

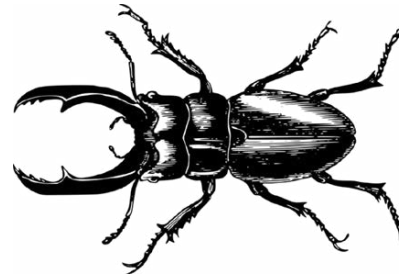
In Vector Cut mode, the software receives information from the print stream and interprets it as a series of paths for the laser head to follow. For the print stream to have vector information, the file being printed must be a vector image. These images are created using mathematical equations rather than pixel blocks. Common vector file types include EPS, AI and SVG. These are easy to resize without losing resolution.



### Vector Cutting

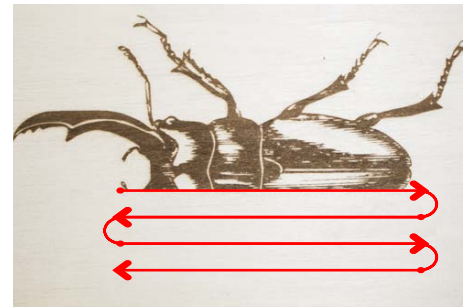
Vector cutting is the most common feature of a laser cutter. Vector cutting with a laser means “to cut a line or shape”. When vector cutting, the laser follows the “vector lines” embedding in the vector image to cut out the design. This process is highly accurate and requires no resolution adjustments because of the properties of a vector image.

## R A S T E R S



### Raster Images

Raster images use multiple colored pixels to form an image. JPEGs, GIFs and PNGs are common raster image types. Most of the photos found on the Internet and photo prints are raster images. Raster images are created using a fixed number of colored pixels, so they can't be dramatically resized without distorting their resolution. Because of this, it is important that you save raster files at precisely the dimensions needed to eliminate possible resolution issues.

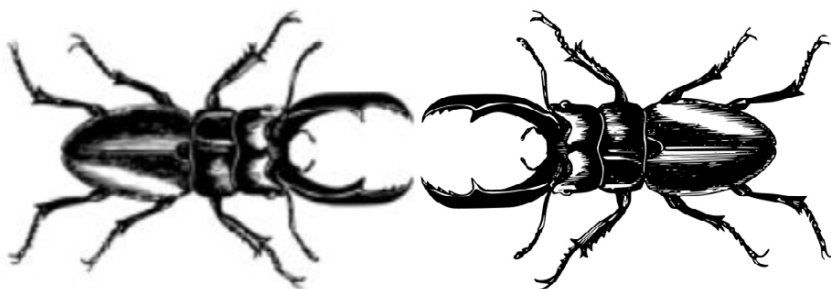
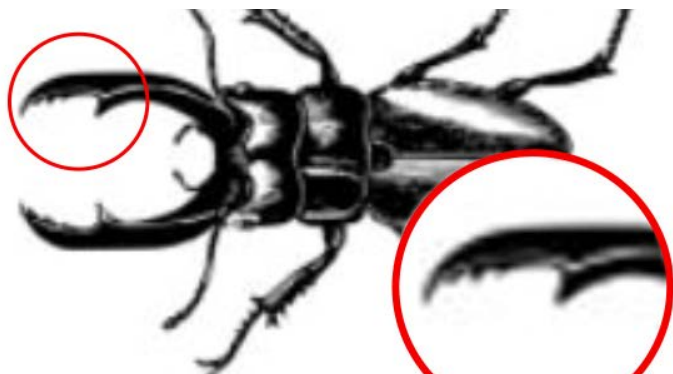


### Raster Engraving

Raster engraving is the process by which complex designs are etched into a workpiece. For raster engraving, a laser has two states: on and off. Every black pixel or “laser dot” is the result of the laser turning on and firing once at a location. This location is controlled by the input image, which can be thought of as a “map” of on and off pixels. The laser fires individual pulses corresponding to pixels in an image. When the laser is operating in raster mode the head moves rapidly from left to right and slowly from top to bottom, engraving your image pixel by pixel and line by line.

## Designing for Basic Raster

A basic raster is a simple engraving, typically of a black and white image. When designing raster projects, keep in mind that the “black” is where the laser is affecting your material. Basic raster outcomes are affected by how you adjust your speed, power, black & white threshold, and Dots Per Inch (DPI). Raster images are made of pixels, which are like tiny squares. You can identify a raster or bitmap image by zooming and identifying these squares. Raster graphics typically have large file sizes, compared to vector images. This is particularly true with images that have high DPI.



### Choosing an Image

Raster image quality is measured by pixel density. The more pixels per inch, the sharper an image will appear. Pixelation occurs when the number of pixels per inch in an image is low, causing each pixel to have visible edges. This distortion becomes worse as the image is enlarged.

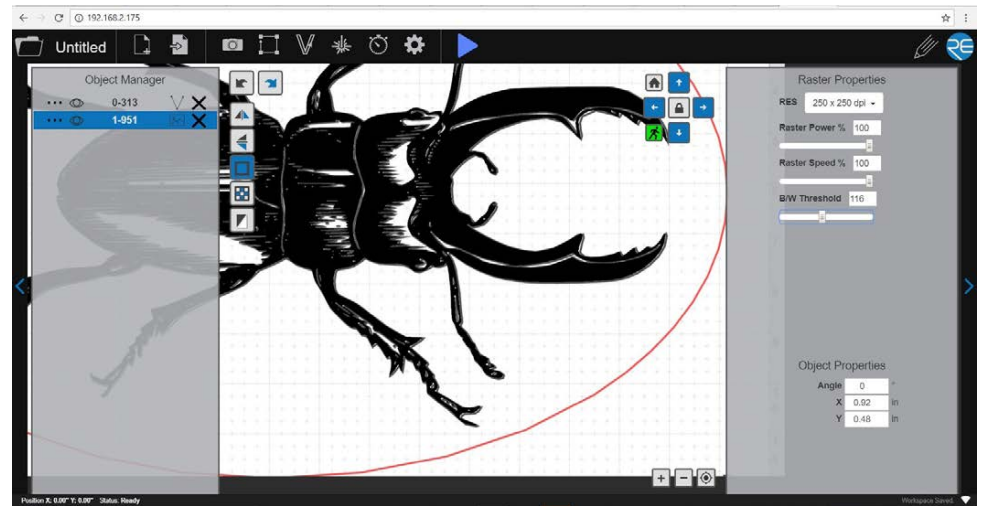
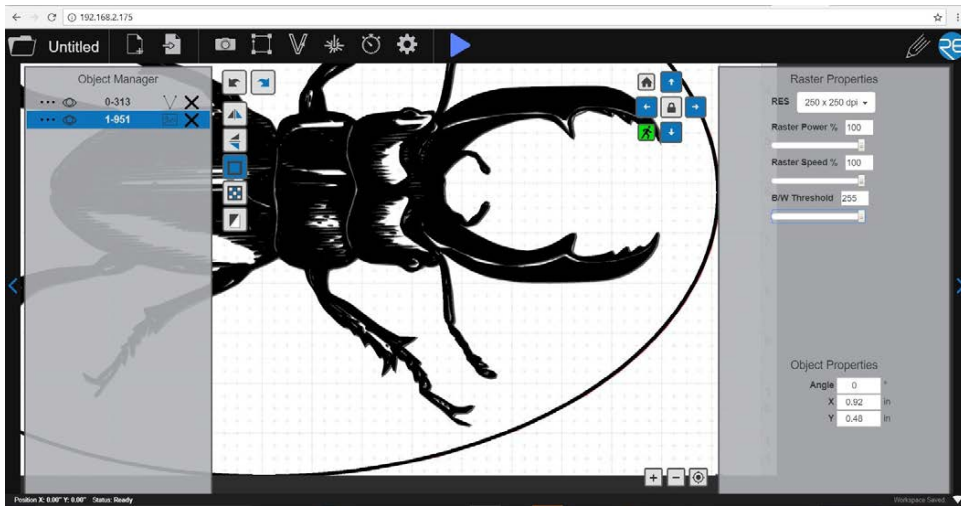
### Create Your Own Design

Tracing bitmaps and converting them into vectors allows you to scale an image while avoiding pixelization from occurring. Because vector images can be engraved as well, they typically work better for a custom basic raster. Vector images are the native format for Illustrator (and Inkscape) and vectorizing images with those programs is an easy process using the Live Trace functions to create your design. Once an image is vectorized, it can be easily scaled and edited without pixelation.



## Black & White Threshold

Other colors (including vector lines in the same design) will register as an engraving if the black and white threshold is not adjusted. The Black & White Threshold application replaces each individual color pixel in an image, with a black or white pixel image. You can adjust the intensity toward black or white, but it is best to find a good contrast.



## Rasters with Vector Lines

If vector lines are present in your raster job, best practice is to make them a lighter color, so they don't register as a raster. If they are still registering as an engraving, simply adjust the b/w threshold to remove the unwanted rastered sections.



### *Designer Tip: Raster Masking*

On non-dithered, deep engravings, to avoid soot depositing on the porous wood, you can use masking tape to have a cleaner outcome. This method replaces the post washing process used for dithered designs.



# Designing for Photo Engraving (Dithering)

Want to use this photo?

[CLICK HERE](#)



The first consideration is the selection of the photo itself. Because our engraving will not be in color, we want to choose a photo that has high-value and high-contrast. Value and contrast are elements of visual design used by artists.



**Contrast** is created by using opposite or juxtaposing elements in an image. Opposite colors on the color wheel, for example, contrast each other. We can also see contrast in value ranges of gray, with the extremes being black and white.

**Value** is how the eye separates one detail in an image from another. Without value images have no distinction and even color is washed out. One trick artists do to evaluate value is to remove all color from an image and examine the image purely in “grayscale”.



## 1 Choose Image

Here we have a photo we want to raster onto wood. We chose a high-resolution image that has a good value and contrast.

**Want to use this photo?**  
[CLICK HERE](#)



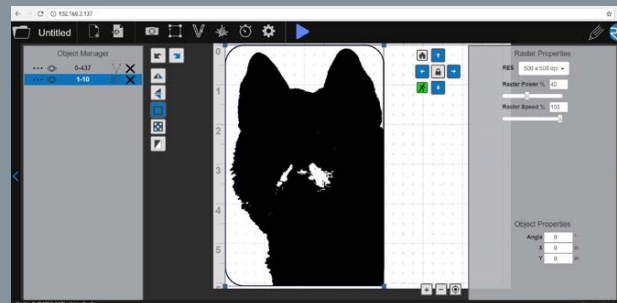
## 2 Crop & Remove Background

In Photoshop, or (similar program), we can crop the image, if needed. We also can remove the background to avoid the background from distracting from the image we want to raster.



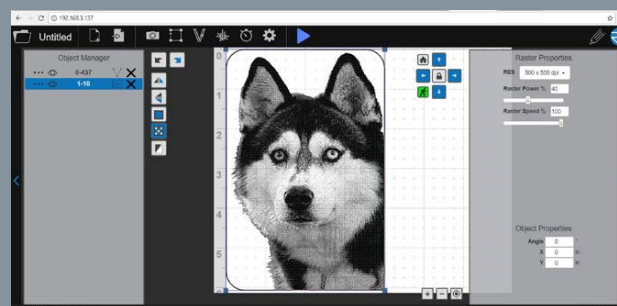
## 3 Convert to Grayscale

Next, we will process the photo into a black and white image. Our laser cutter software will automatically convert images to black and white, but for the best results, we are going to first adjust our image in Photoshop.



## 4 Import & Resolution

Import the image to your laser software. Now we want to adjust our resolution. Resolution is determined by DPI, or Dots Per Inch. The more dots per inch, the higher precision and quality of your images, while a lower DPI will process and engrave faster. For most image engraving, 500 DPI is perfect.



## 5 Dither

Now, we will dither our image with the laser software. Dithering helps define how the dot patterns will be engraved.

# RASTER PROCESS CONTINUED



## Results

This process should give you maximum raster quality, but you will still need to experiment with power / speed settings depending on your material. Remember, with experience comes better results.



## Preserving Results

To preserve contrast, instead of cleaning with a rag, wash under a mild flow of room temperature water. Hold the piece vertically and allow the water to gently wash off excess residue. Then let it air dry and add a light stain or clear coat to protect and preserve the piece.



## Negative Image

In some cases, when rastering on dark material, such as black tile or stone, our image will need to be flipped to a negative image. This will switch all the black and white to be reverse images of the original image creating the contrast we want.



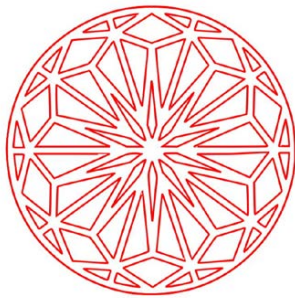
## Negative Image on Black Material

Here we see what negative imaging looks like when the image is rastered on black acrylic.



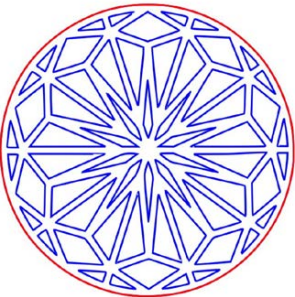
## Designing for Vector Cutting

In this example, we start with a basic design pattern we created in Illustrator as a vector file and saved as a PDF. With this one design, we can create multiple outcomes with just minor design variations in your design software.



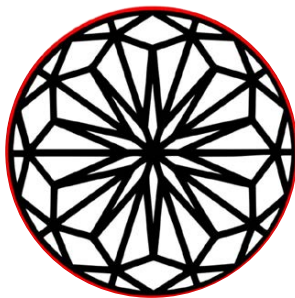
### Basic Vector Cut

Here is a simple vector cut of the pattern. In the software, the red lines tell the laser what to cut. All red lines will be cut through the material creating the empty space in the final project.



### Vector Marking

We can outline (as opposed to fill) parts of the pattern for a second design option. Again, we will instruct the laser using our vector properties. In this design, the blue lines will not be cut through on our material, but instead will be marked.

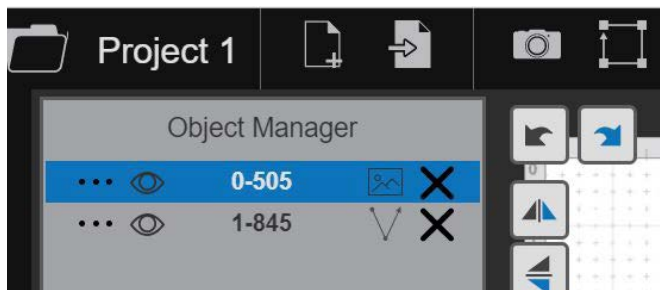
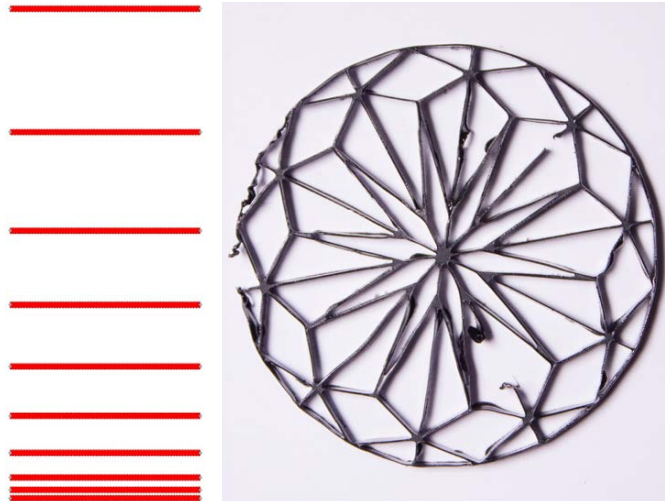
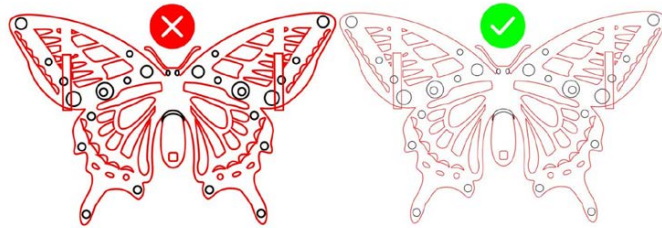


### Vector Cut With Raster Fill

We can also combine vector cutting with engraving. In this case the laser will raster in the black fill and cut the red line.



Vector cutting is a simple operation for a laser cutter; however, good design is key to achieve high-quality results.



## Setting Stroke Thickness

The laser spot is about 0.005" in diameter. To avoid the laser making a double pass or cutting two lines, we want to set the thickness of our vector line to the smallest "stroke" (in Illustrator, this is called "hairline").

## Vector Line Spacing

When the laser "cuts" it is actually vaporizing material away. This means the designer needs to be aware of additional spacing between lines in the design stage. If spacing is too close, then your vector cuts may be too thin and break.

For example, acrylic doesn't char on the edge like wood or paper, its edge melts. In turn, if a design has very thin cuts or has small details, a high, less dialed in power setting might distort or even melt the fine details away. Knowing the tolerances on the material you are working with helps you design for success.

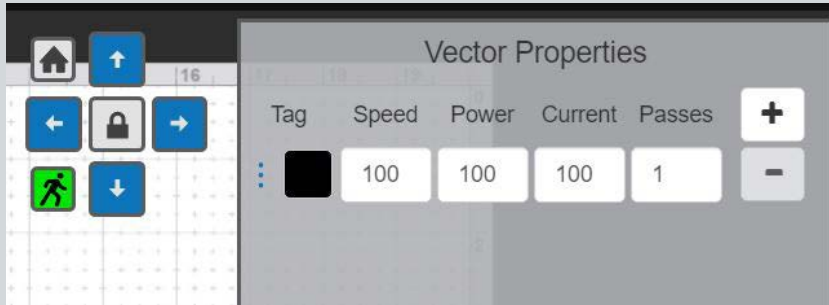
## Order of Operations

If you are combining vector and raster technique in the same job, consider the order of operations carefully. If you vector cut the shape before you fill in the design, your piece may slip from the material, offsetting everything that comes after. Set your raster engravings to be first and your vector cuts last.



## Achieving Ideal Edge Burn

Differing degrees of edge burn come from power settings. Too much power and the edge will be black with soot coming off on your finger when the edge is touched. Ideally, for wood, we want a rich amber color and very little soot rubbing off.



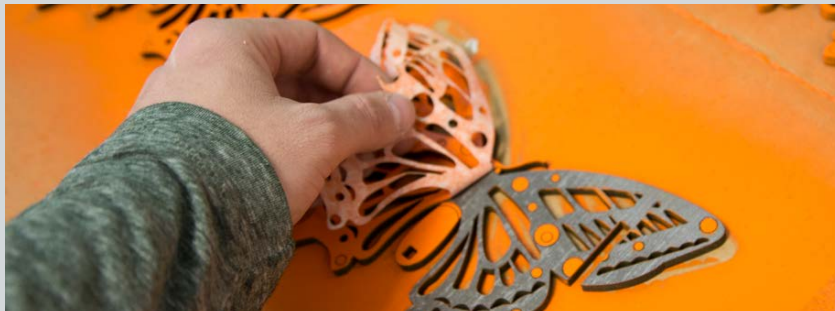
## Reducing Burnt Edges

For vector cuts, dialing in power settings is key to reduce char on materials, such as wood. If speed and power adjustments aren't enough to reduce char on your vector cut edges, try adjusting your vector current to dial in your cut even more.



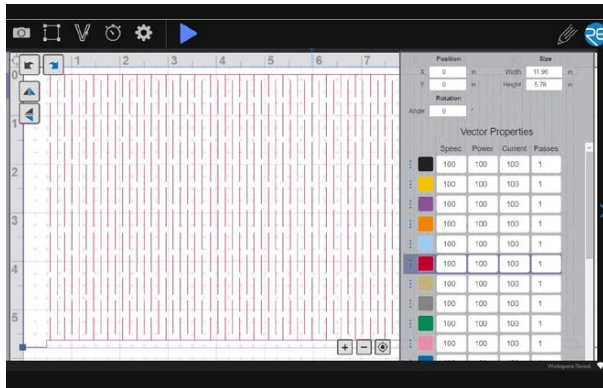
## Adjusting Current

Besides power and speed, vector current is a third option that can be dialed in to create a better cut. This is particularly apparent on paper, as it cuts very easily but tends to burn on the edges. To reduce charring on the edge of thin paper, vector current can be lowered as low as 20 percent with a low power setting and still effect the paper.



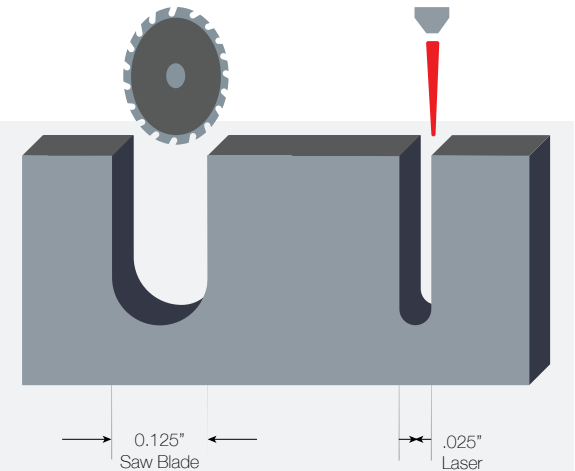
## Vector Masking

Vector marking is great for creating stencils on top of projects. By adding a layer of masking tape you can use the vector marks to cut through just the surface of the tape creating a stencil on top of your design. Simply remove the tape where you want to paint. This makes painting any project very quick and precise.



## What is Kerf?

Kerf refers to the amount of material that is removed when cutting. Compared to other cutting methods, a laser has a very small kerf.



## Utilizing Kerf in Designing Living Hinges

There are many variations on the standard design to create living hinges with kerf, but they look something close to this pattern of overlapping vector lines. Each line will be vector cut, removing material in strategic places that will give the piece flexibility. For this pattern, we would require fairly thin wood material, no more than .25". As the thickness of the material increases, we will have to increase the amount of material removed. In general, the radius of the bend depends on the length of the cuts, the distance between them and the thickness of the material.

## Assessing Flexibility

When assessing our material's flexibility, we are looking for the following: Pliability (how easy it bends), Tensile Strength (how fragile it is while bending) and Torsional Strength (how fragile it is when twisted). The ultimate goal is to remove the minimum amount of material possible. This will maximize the overall strength of the piece as well as save time and money in the actual cutting process.



## Designing Notches for 3D Objects

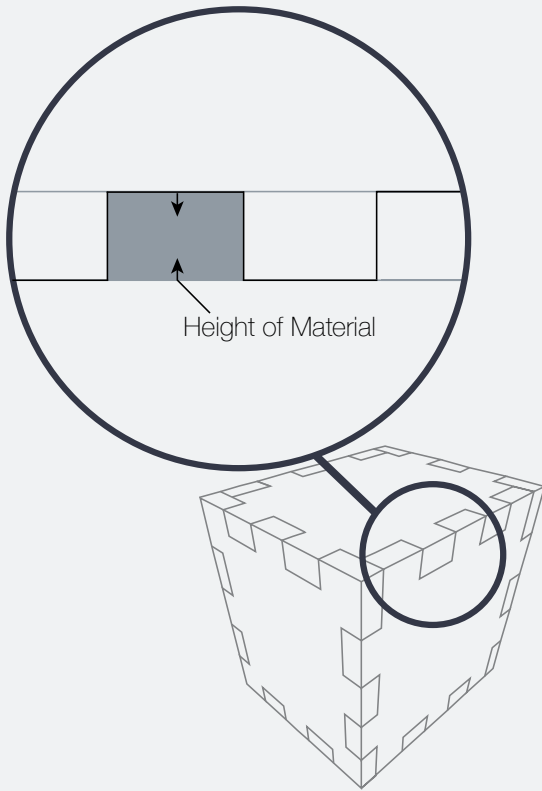


Notching is a technique that makes 3-dimensional laser cut projects easy to design, create and assemble. Notches allow us to add stability as well as a method to hold our individual pieces together. By using different designs of notches, we can also create projects with many looks and purposes.

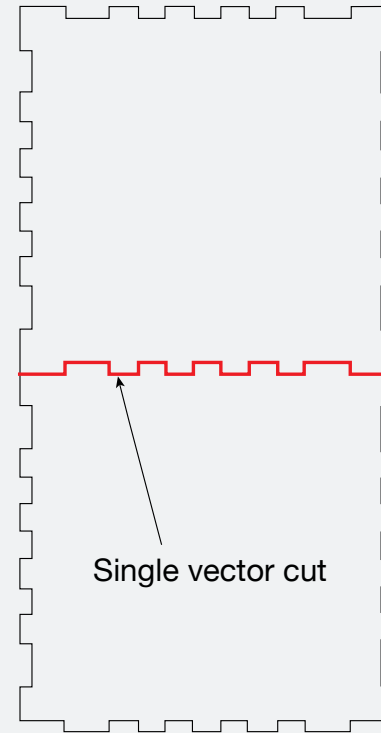


When creating notches, an accurate measurement of the material height is crucial. Because material can vary in thickness, we recommend using calipers to get a precise measurement.

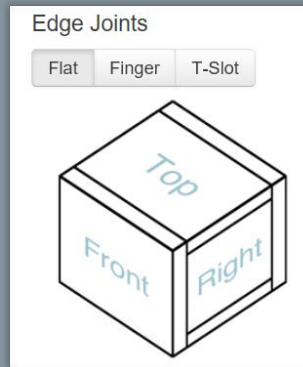
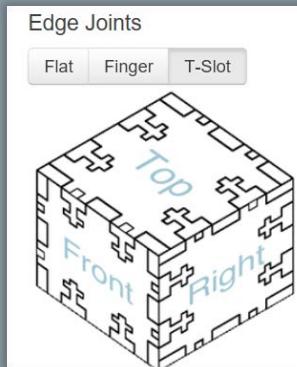
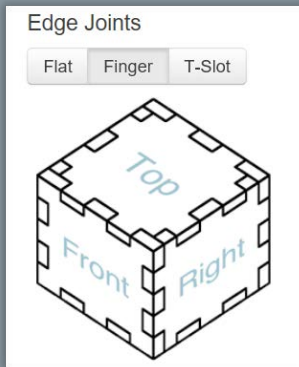




When you're designing notches in your favorite software, you need to consider the thickness of your material, as this will indicate the height of your notch.



Because the laser cuts such a precise line, you don't need to plan for spacing to align your joints in assembly. You can simply share vector lines with a single vector cut. This will save time and material and the piece will slide together perfectly.

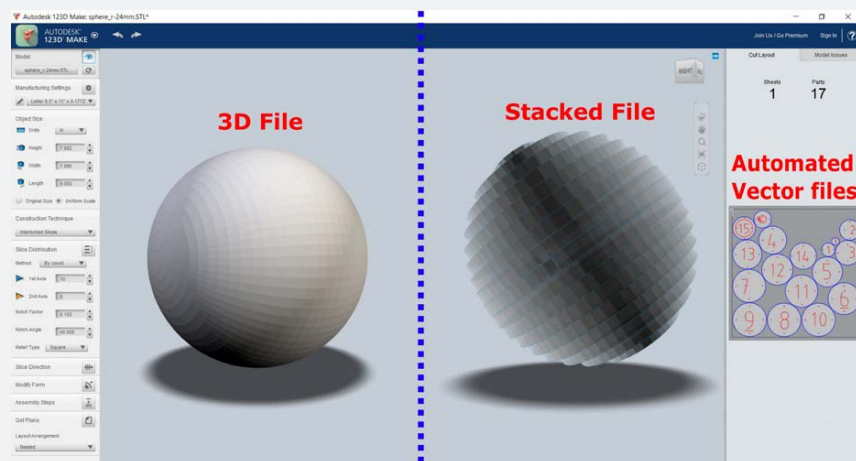


## Design Tip

If designing your own notches seems a bit intimidating, at first, you can access digital applications that automatically process simple notched boxes. A browser-based application called MakerCase ([www.makercase.com](http://www.makercase.com)) works well for this and is free. All the designer needs to do to make a simple notched box is fill in the information windows, including the dimensions you want to use. Once you are comfortable with the concept of making notches, you can advance to making your own custom notches using your own design software (such as Autodesk 123D Make).

# Stacking Techniques

Stacking is another technique to create 3D projects from flat laser cut material. Using design software we can create a series of “slices” to dissect a 3D object into layers. These layers can then be cut on flat material with our laser and assembled to create our final 3D object.



## Auto Stacking Software

The easiest method to create stacking projects is by using design software to generate laser vector files from a pre-existing 3D object file. After entering your desired dimensions for the material, and the dimensions of your laser bed, the software automatically creates the layers and organizes them into viewable pieces, complete with assembly instructions. You can then import the file as a PDF to your laser software or to your favorite editing software for further customization.



## Original Stacking Designs

Although there are many pre-designed 3D object files you can find and use, as a designer, the concepts you can conceive yourself will be the most satisfying. Original 3D stacking projects can be created freeform by imagining each layer in your design as it relates to the next. Once you are comfortable with simple shapes, you can explore and iterate endless concepts.

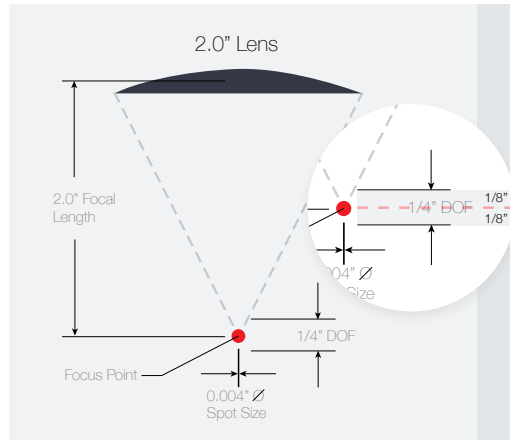
# Focusing Uneven Surfaces



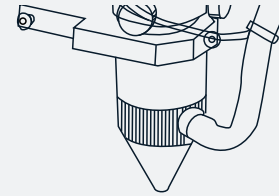
Not all projects are perfect flat pieces of material. Some applications might have uneven surfaces. In this case, one might be confused on how to focus the laser for the best output onto a given item.



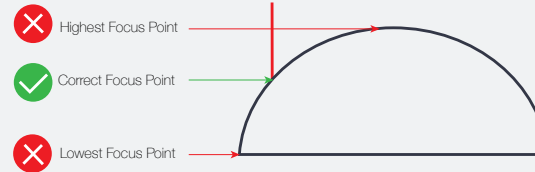
When a design comes out of focus range, the output will become blurred, distorted and/or faded.



To help correct this, with a 2.0" focal lens, the laser can be out of focus up to 1/8 of an inch either way and still achieve a good raster engraving.



Focus lenses can vary in length and each will have a different depth of effective focus.



**Splitting the Difference** For the best results you will have to split the difference between the highest point and the lowest point of your piece. Using a standard 2.0" focus lens, you have a depth of field of a 1/4 inch to achieve your raster on a uneven surfaces with a hobby laser. This means you have 1/8th of an inch below and above the focus point.

Two Separate Files



**Breaking Up Uneven Surfaces** Some designs will have to be broken up into separate files. If a given project has two different heights that are outside of 1/8 of an inches of difference, then you will have to break up your design into multiple files and focus and cut each separately.

# MATERIALS

C02 lasers can affect a variety of materials in various ways. This section is to inform you on how individual materials can be affected by the laser cutter. This will give you an idea of how you can design for specific materials and what to expect when translating your design from a simple file on the computer to the output on your chosen medium.

## APPROACHING DESIGN WITH MATERIAL IN MIND.



### Acrylic

ENGRAVE ● CUT ● MARK ●

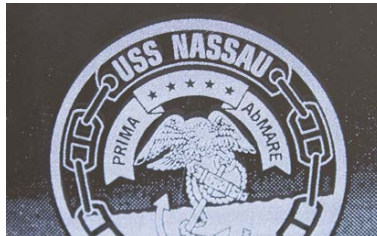
Acrylic comes in many different colors and effects. When marked properly, its appearance will range from “frosty” to a translucent sparkly outcome. It is important to choose the right type of acrylic for a smooth edge. Cast acrylic is preferred with engraving.



### Wood

ENGRAVE ● CUT ● MARK ●

Wood can have many variables from piece to piece, even if from the same source. Knots, grain density and even glue can make cutting and engraving inconsistent, so choosing the right type and quality of wood is crucial for outcome.



### Glass

ENGRAVE ● CUT ○ MARK ●

Properly engraved glass can range in appearance from “frosty” to “sparkly”. When glass reacts with the laser, the visual output you see is tiny microfractures of the glass itself. This means you only want to design with non-vector in mind.



### Metal

ENGRAVE ○ CUT ○ MARK ●

Metal cannot be directly affected by a C02 laser. That said, we can mark metals using chemically formulated additives that permanently fuse to metals. Painted and anodized metals can also be etched by removing their topcoats to reveal the metal underneath.



## Material Recommendations

The higher quality material, the better the results will be. For wood projects, we use Rowmark's Hardwood Collection because it is designed for laser cutting and engraving, and gives much more consistent results than normal wood. Kerf bending and notching projects greatly benefit from this product because wood can have uneven thickness. For acrylics, we recommend Rowmark's laser and rotary engravable plastics. These are also high quality, high consistency materials made specifically for laser engraving.

### APPROACHING DESIGN WITH MATERIAL IN MIND.



#### Rubber

ENGRAVE ● CUT ● MARK ●

Rubber is most commonly used for creating gaskets or rubber stamps. When designing a rubber stamp, remember that the design will have to be inverted, meaning the material around the image will be cut away leaving a raised surface on the stamp.



#### Fabric

ENGRAVE ● CUT ● MARK ●

*(Depending on which fabric)*

Fabrics vary in results, when laser cut. Denim cuts and engraves well. Polyester cuts well, but doesn't engrave cleanly. Plastic based fabrics are great for cutting patterns, as the edges melt and seal under the laser, greatly reducing fraying.



#### Leather

ENGRAVE ● CUT ● MARK ●

Leather can be very fibrous, which can cause difficulty when attempting a clean cut on thin material. For leather, thicker, high-quality material is suggested for its denser fiber construction. Leather also can create flames, so monitor your leather cutting closely.



#### Stone

ENGRAVE ● CUT ○ MARK ●

Always use a polished stone or quality tile. Choosing darker shades of stone will highlight the contrast of the engraving much better than lighter colors. You can run raster files onto stone with great results using dithered images.

## Software used for this ebook:

Industry Leading [RetinaEngrave 2.0](#), [Photoshop](#), [Autodesk 123D Maker](#), [Inkscape](#), [www.makercase.com](#)

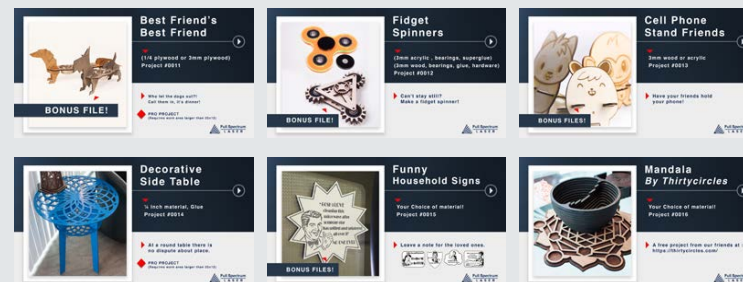


## Additional Resources

This ebook is only part of a host of free resources for laser cutting and laser engravings, presented by Full Spectrum Laser. Our website ([www.fslaser.com](#)) offers many other teaching and laser operation material for both amateurs and experts, alike.

## The FSL Free Project Catalog [Here](#)

Looking for your next great project? We offer free project files you can use as is or as a base to iterate your own designs. All projects are created by our in-house artists and are completely unique and original, with new projects added every week!



## Material Logs

Material Logs are highly recommended. We offer a free materials log and a material test template for free at the Full Spectrum Laser website. [Get Yours Here!](#)

## Video Tutorials

Want more? We offer a complete library of video instructions for many common operations and upkeep of a CO2 laser engraver. Series includes:

[Product Showcases](#)

[Assembly](#)

[Operating Your Laser](#)

[And more!](#)

[Unboxing](#)

[Mirror Alignment](#)

[Upkeep & Maintenance](#)



## The Laser Experts Blog [HERE](#)

Our in depth analysis of everything that involves laser cutters and engravers presented in an on-going series of blogs aimed at makers and professionals alike.

## Laser 101

Need a little boost to gain confidence in your laser cutting skills? Laser 101 teaches you the basics of using a laser cutter with free step-by-step lessons for three experience levels.



### [Beginner Lessons](#)

It all begins here! In these hands-on lessons you'll learn the basics of what your laser is capable of. You'll learn to engrave, cut with vectors, mark with vectors, and combine functions to make fun projects.



### [Intermediate Lessons](#)

Put it all together as you combine techniques with skill and confidence to create your heart's desire.



### [Advanced Projects](#)

Put it all together as you combine techniques with skill and confidence to create your heart's desire.

## The Full Spectrum Laser Certification Program

Certification demonstrates you have gone through the rigors of training for laser safety and machine operations. Get your certificate today.



### [C02 Laser Safety Certification](#)

Safety comes first. Learn to use your laser cutter safely before you start your first project. Includes fire, electrical, laser and workshop safety procedures and protocols.



### [Muse Laser Cutter Certification](#)

Become a certified Muse operator with a complete overview of operations, hardware and software.



### [Hobby Series Laser Cutter Certification](#)

Get ready to impress with a Hobby Series certification and become the lead laser expert at your local maker-space.



### [Pro-Series Laser Cutter Certification](#)

Demonstrate mastery of industrial Pro-Series laser cutters to your next employer with a Pro-Series certification on your resume.

## COMING SOON!



### **Laser Operations:**

Gain a deeper understanding how lasers and laser engravers work as this ebook guides you on an in depth look at the mechanics of laser cutting.



### **Lasering in the Material World:**

Laser cutters do more than just cut wood. This ebook will demonstrate the properties of a host of materials and how they are affected by a laser cutter.

## THANKS TO:

This Ebook was created in-house, at Full Spectrum Laser's facilities in sunny Las Vegas, NV.

Creative Director: Nick Barr

Lead Graphic Artist: Brooke Vreeland

Lead Designer: Walker McKaeg

Graphics: Alysha Press

Editing: Gregory Scott