

Laser Design Basics

All drawing software works pretty much the same way, the only thing that changes are the names of the tools and where they are hidden in each program. If you understand the concepts behind working with rasters and vectors, you can pretty much use *any* drawing software to knock out some great personal creations.

Below are just a few brief descriptions of some things that are extremely helpful to know before you start.

What is the Difference between a Raster Image and a Vector Image?

There are two types of digital image files, raster and vector. Each is defined by how it is created. Each type has its pros and cons for various uses, and it's important to understand the differences between the two to use them in design.

Raster Images:

Raster images are created by laying down thousands of little square dots of color called pixels. If you zoom in far enough on a raster image, you can see the pixels.

Types of raster images:

- Photographs
- Hand Drawn and Scanned Artwork
- Most Photoshop, Gimp and CorelPaint artwork
- Vectors that have been Rasterized
(*turned into squares of color*)

Common Raster File extensions:

- Jpegs (.jpg and .jpeg)
- Bitmaps (.bmp)
- Ping (.png)



Pros:

Raster Files allow for more natural blending of colors, making them great for photos and artistic work. The smaller the dots of color are, the more pixels that can be fit into an inch of space. This is called ppi or pixels per inch. The higher the ppi, the higher the resolution of the photo, and the result is a better image.

Cons:

If you try to use a raster file that has a very low ppi, the image can't be scaled up in size without causing the individual pixels to become visible as jagged edges. This can cause a problem when you are trying to turn a raster into a vector, and everything you do on a laser **has** to be turned into a vector first. The vector is what tells the machine how to move.

*(Note: The Glowforge software does some automatic vectorization **for you** on raster images, but your results are only going to be as good as the file you start out with. If you start out with something low resolution, you aren't going to get great results. And anything you get from the internet is **low** resolution.)* Shoot for a resolution on your raster images of around 300 ppi when you scan. It's more than enough for terrific results.

Vector Images:

Vector images are defined by a mathematical equation. (*Yeah, scary thought.*) But the good news is that the drawing program will handle all of the math, and all we have to do is draw points and play Connect-the-Dots with lines.

Types of Vector images:

- Clipart
- Dingbats
- CAD drawings and Line Art
- Fonts
- Most AI, Inkscape and CorelDraw artwork
(*drawing programs*)
- Rasters that have been Vectorized
(*turned into lines and fills*)



Common Vector File extensions:

- **.SVG (used by the Glowforge)**
- .DXF
- .AI, .CDR, .EPS, etc.
- .PDF (*PDF can be raster or vector*)

Pros:

Vectors can be scaled up or down to any size without losing resolution. Vector files are generally much smaller than photographs, making them quick to upload and download. In addition, the lines and fills that create the images tell the laser what you want it to do. Without those lines, the laser doesn't know the path you want it to follow for burning, and all it can do is fill in a solid block of color like it does for a raster engrave.

Cons:

Vector images tend to be cartoon-like compared to photographs, with clearly defined sharp edges. The colors that fill each section are generally a single shade, without the blending of shades seen in a raster image.

When you design for a laser, you will be able to use both raster and vector elements. They can be in the same file, or they can be in separate files that consist of only one or the other type of image. **Raster images (pixels) are always Engraved.** Vector files that you create in one of the 2D drawing programs like Adobe Illustrator, Inkscape, CorelDRAW or Affinity Designer can be **Engraved, Cut,** and/or **Scored,** depending on the parts that you use to create them.

The Glowforge User Interface (GFUI) has a method of directly adding vector Cut and Score Lines to your raster artwork. These vectors will enable you to cut out around your image, or add score lines to the engraving. This is called the **Trace** function in the GFUI, and it is very easy to use for a beginner. (Literally drag, point and click.)

But you can also create your own vector and raster combinations in any of the drawing programs mentioned above, and doing so will give you more control over the results. If you do decide to try designing your own vector files, you need to understand what parts make up a vector, and follow a few guidelines, to create a laser-ready file for the Glowforge.

In order to understand vectors, we need to know a little bit about how they are constructed. Vectors consist of several parts, and each of those parts has certain characteristics we need to know in order to use them.

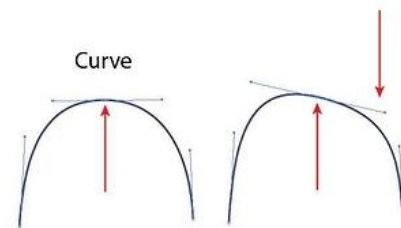
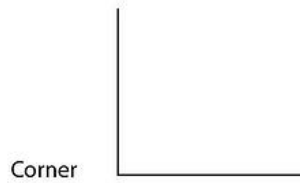
What are the Parts of a Vector?

Points (Also called **Nodes**, **Anchors** or **Control Points**.)

There are two kinds of points – **Corner** points and **Curve** (Smooth) points.

Corner Points : With a corner point, the lines that connect at that point are locked. Basically it's a place where an instant direction change occurs as you follow along the path.

Curve Points define a relationship between the two lines that are attached to them on either side. When one of these lines is adjusted, the other line will compensate. (These curves are commonly known as *Bezier Curves*, and there are separate tutorials that explain how to use them.)



Line Segments

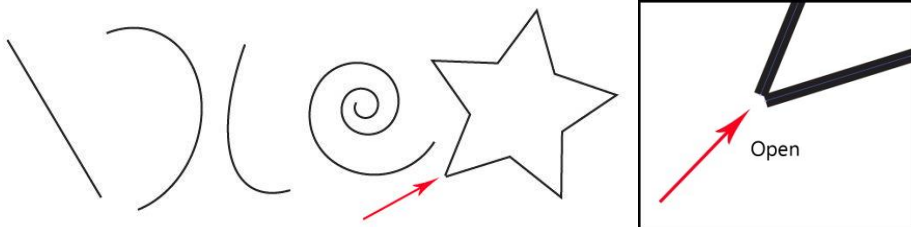
These are the straight or curved lines that are drawn from point to point to create a shape.

Paths or Vector Paths (These can also be called **Lines**, **Strokes** or **Outlines**.)

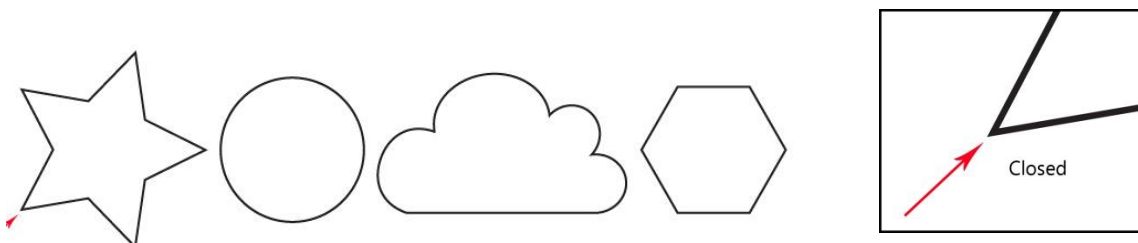
These are the line segments **and** the points. They can be straight or curved into whatever shape is desired. The vector path is what the laser follows when it performs a cut or a score operation.

Paths can be open or closed into a shape.

Open Paths:



Closed Paths:



Fills

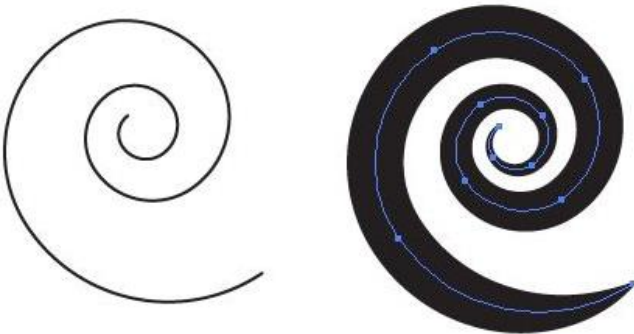
Closed shapes can be **Filled** with a color, or they can have no fill (*null Fill*). These color fills are pixels of the same color, filling up the area enclosed by a vector path. The laser is going to interpret any Fill color that it sees, **including a White vector fill color**, as something that you want to be engraved. So if you have an area in your design that you do not want to be engraved, be sure to set the Fill to **none** for that shape.

(This can be accomplished through the use of Compound Paths and use of the Subtraction/Difference tools, and is covered in other tutorials.)

Strokes

Although the term “Stroke” (or Outline) is often used when describing vector paths, in reality they are treated differently by the laser. By default in most drawing programs the vector path, (which is what the laser sees), will run down the center of the Stroke (Outline). The stroke is just a decorative element applied over the top of the path. *(Think of the vector path as a pencil line, and the stroke as a highlighter line over the top of it. You can color with the highlighter on either side of the pencil line or centered over the top of it, or make the stroke as wide or as narrow as you like, but the pencil line is going to stay in the same place. The laser is always going to cut or score along the pencil line.)*

For example, the laser sees the same thing from a cutting standpoint in each of the images below. It is going to make a cut in the shape of the left spiral.



If you want the laser to actually cut out around the plumper spiral on the right, you have to either **Expand the Appearance** of the stroke, or **Convert the Stroke to a Path** in order to place **Cut** lines around the outside of the thick black stroke shown. *(There are tutorials available to show how to do this.)*

Drawing programs were created for making drawings, which frequently result in something that **appears** different from the actual construction underneath. The laser is going to see the construction, not the embellishments, unless you take some steps to convert the appearance into a closed shape whose construction matches the appearance.

Color

Color is an extremely important part of the vector design process, especially as applied to lasers. Assigning different colors to certain parts of your design will enable you to perform different operations on the various parts.

(Engrave, Score, or Cut.)

Strokes (Outlines) can have different colors assigned to them, or they can have no color (*null Stroke*).

If you do not assign a color to a Stroke or a Fill, the underlying vector path will be ignored by the Glowforge interface in your design.

Fills can be the same color as the Stroke, or they can be a different color, or they can have no color (*null Fill*).

If a shape has null Stroke color **and** null Fill color, you won't be able to see it until it is selected, **but it still exists**. This can cause a lot of confusion for beginners when they accidentally misplace their shapes because they neglected to assign a color or opacity value to them. If you select everything on the board the hiding shapes will become visible, and you can assign a Stroke or Fill color, as desired. *(As long as there is no Fill or Stroke color assigned to those shapes though, they will not be picked up by the Glowforge user interface.)*

Text & Fonts

Letters and Numbers are nothing more than vector shapes, but Fonts are a special kind of "flexible" vector that usually exists as a Fill with no Stroke color associated with it. So they require special treatment if you want to cut them instead of engraving them.

They consist of a path that outlines the shape of the letter, but there is usually not a color assigned to the Stroke for it. Fonts are installed onto your computer, which means that you can then use them in your designing. You can change the size of the font easily by filling in a blank, or completely change the appearance of the font by switching to a different font. The words and letters you have typed will not change. But there are a couple of things to remember about using them.

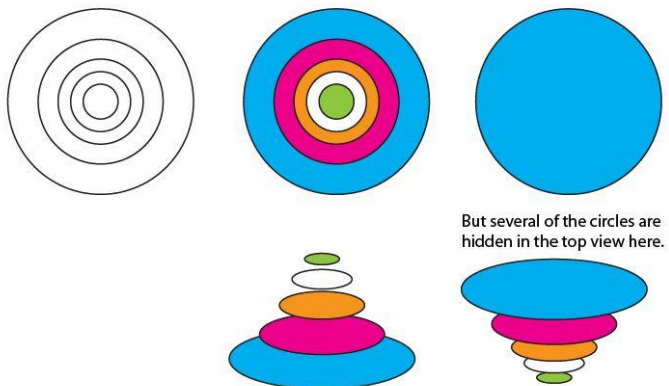
The same font can be slightly different between different operating systems, and the program picking them up might have a different version. Also, if you are using a special font in a design, you have to know that the program picking up your design for interpretation **also** contains the same exact font. Otherwise it will substitute whatever it has that is kind of close. This can lead to some very amusing (*and frustrating*) accidents with your design.

In addition, if you want to edit the shape of a particular letter, you have to **Convert to Path** before you can edit the shapes. This extra step is necessary because of the special nature of fonts. Once the text has been converted into a path, it will show up exactly as you want it in your designing. *(It stops being flexible.)*

Layers

Designing with vectors involves nothing more than stacking shapes on top of one another, to come up with an overall picture. Certain operations in the design program will allow you to punch one object either up or down through another object; merge two overlapping objects into one whole; choose the parts that overlap and get rid of everything else; get rid of only the parts

Laser will see the same thing from a vector line perspective for all three of these objects.



that overlap, or just divide the overlapping shapes into parts where the paths cross each other.

You have to be aware of where each part of the design falls in the **Layer** stack. There is a Layer viewing option in each drawing program, and you can move the parts on one layer up and down in the stack. This is something to watch for, since you can have a part or line hiding underneath something that is **Filled** with color or even a shape that has a white **Fill** color.

Those are the basic parts of vectors. Drawing programs such as Adobe Illustrator, Inkscape and CorelDRAW will give you a multitude of options for grouping and aligning parts of a design; changing the size to fit specific parameters that you want to use, both individually and by scaling the whole as a unit; creating radial copies of parts of a design; and creating arrays.

Designing for the Laser

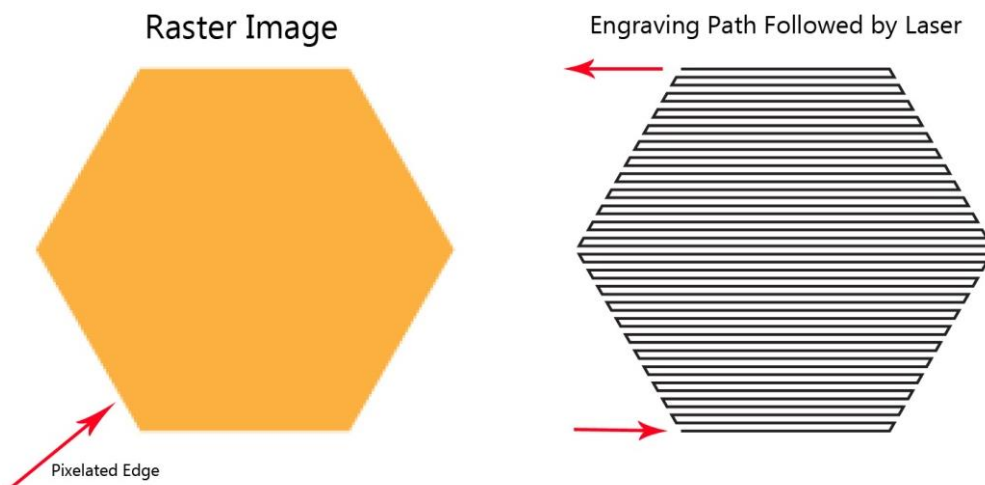
Lasers can do three things by following your design, they can:

- **Engrave** – burn away some of the material without cutting all the way through.
- **Score** – burn partially down while following a **single vector path** without cutting all the way through.
- **Cut** – burn completely through the material while following a vector path.

Engraving with a Laser

When the Glowforge User Interface (GFUI) sees **pixels** in your design, such as a **Raster** image or a **Fill** from a vector shape, it is going to interpret that as something that you want to be **Engraved**.

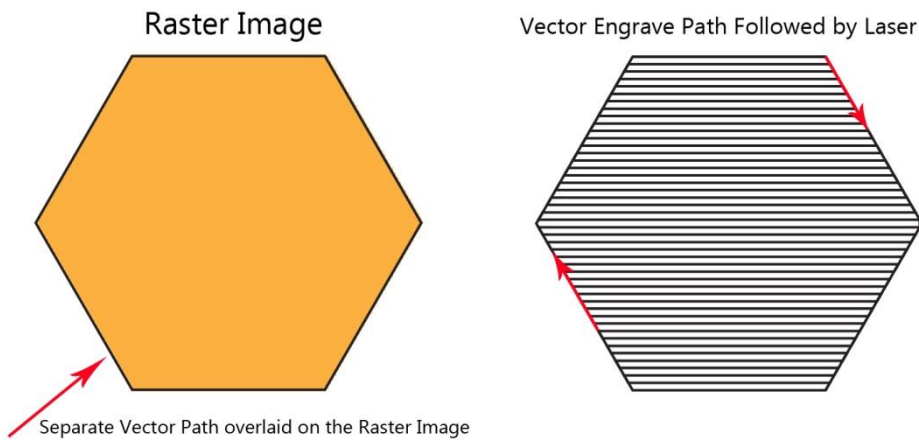
The laser will fill in the color for that pixel filled area by creating a path to follow that will fill in the shape solidly, similar to the simple raster image below:



The more closely the lines that fill in the shape are spaced (Lines Per Inch) the more solid-looking the final result is going to be. *(And the longer it will take to finish.)* Filling in solid areas with a laser beam, which is incredibly small, takes a lot longer than just cutting something out. *(Engraving is a relatively slow laser process.)*

Scoring with a Laser

Scoring is like engraving for a single line, and the path the laser follows is the same one followed for cutting. It traces along a vector path that has been created in the design.



Both the engraving and the scoring functions in the Glowforge can be set for light/dark values, so you can create a nice darker outline around your engraving by using a separate vector Score line in your design.

Cutting with a Laser

Cutting works the same way as scoring – the laser follows the vector paths that it sees, but it's going to cut all the way through the material.

Tips for designing specifically for the Glowforge are going to start on the next page, but there is one more thing to discuss before we get to that point. At the start of the tutorial, I mentioned that rasters had to be turned into vectors before the laser would know what to do with them. If it sees a raster, the only thing it can do is engrave it.

If you want to add vector paths to a raster image, such as paths for cutting out part of a design or adding a score line, you will probably want to use an Auto-Trace function. Glowforge has the Trace function built into its interface, and the major 2D Drawing programs have them.

There are tutorials explaining how to effectively use the Auto-Trace options in most of the major drawing programs. But there are limitations to how effective an auto-trace can be if you are starting out with a poor image. Sometimes images need to be cleaned up before tracing, and cluttered backgrounds removed before a good trace can be obtained. That kind of cleanup is best performed in one of the **Raster programs**, such as Photoshop, GIMP or CorelPaint. *(And there are tutorials for that as well.)*

Some Tricks for Designing for the Glowforge:

Raster Files

1. If you are working with a Raster Image (pixels) – the Glowforge User Interface (GFUI) will assign an **Engrave** operation to it.
2. If you want to add a **Cut** or **Score** around or inside of your engraving, use the **Trace** function in the GFUI to add a vector path, or an Auto-Trace function in one of the other 2D Drawing programs (Illustrator, Inkscape, CorelDRAW).
3. When performing a trace or auto-trace of any kind, best results are obtained from starting with a higher resolution image – at least 300 ppi.
4. You might have to clean up the image or remove the background in order to get a nice clean trace. That process is performed (*before tracing*) in one of the raster programs (Photoshop, GIMP).
5. If you want to use a raster image inside of a vector file, you will want to **Embed the image** into the file when you save it.
6. The Glowforge User Interface will ignore white pixels when engraving in a raster type image file.

Vector Files

1. When you create an empty vector path (*one without a fill color*) and assign a stroke color to it, the Glowforge interface will initially treat it as a **Cut** operation.

You can convert this line into a **Score** operation in the GFUI, by selecting the thumbnail in the left hand column, and clicking the little dropdown arrow at the upper right, in the gray bar.

2. If you want to have both a **Score** and a **Cut** operation in the same file, use a different line color for each operation. (For example: Set all the lines you want to be Scored as red, and all the lines that you want to Cut as blue, and all of the fill that you want to be Engraved as black. Or if you want to engrave one part first, and another part second, you can set the fill colors for the engraves to be different, and then order the operations in the GFUI. Then you could engrave one area first, and come back and engrave a deeper spot in the first area in a second pass.

Each color that you use in your vector design will give you the option for a separate operation to be performed on it.

3. If you want to do a vector engrave on a filled shape, do not set a stroke color for that shape. The GFUI might interpret it as a **Cut** when it sees the stroke color.
4. If you want to add a **Score** line around an **Engraved** area, copy the path for the Engraved area, put it on a different layer, (*or sub-layer*), and give it a different color. This will cause the GFUI to assign a different operation to the line.
5. **Vectorized** White Fill is considered an **engrave color** in the Glowforge software. If you have a design that has what appear to be white shapes overlaying another color, the GFUI is going to see that as a solid block of engraving.

Use the **Subtraction** and **Difference** tools in your design software to create an actual void in the spaces where the white fills are located. The resulting engraving will then come out looking like you want it to look.

An alternative that works very well for engraves is to select all of the engraving, convert it to a raster image, and let

the GFUI treat it as an engrave of pixels. This method is sometimes easier for beginners, but the result is not as nice as a vector engrave of a fill.

6. If you are using a special text, and you want it to appear exactly as you have created it, convert the text to a path before saving the SVG file. Otherwise another font may be substituted.
7. If the file that has been exported as an SVG contains a true raster image, (pixels), the raster is ignored by the Glowforge software unless it has been embedded, and must be re-imported into the file and placed using the camera. (*Visual alignment.*) Vectorized images will be recognized within the original SVG file as needing to be engraved without re-importing . (*ie: Vectorized Fills without a Stroke.*)
8. You can import raster images to overlay on an open vector file in the Glowforge interface, but you cannot import and overlay another vector file. (*At this time. – Note: updated. You can now add a vector file as well, through drag and drop or the Add Artwork button.*)

If you want to perform multiple operations in a file, create all of the vector lines in the same file, using different colors for the lines according to the operation you want to perform on it, and save it as an SVG before you bring it into the Glowforge interface. Use the Design Catalog to load the SVG file.

9. **Current** file types that the Glowforge software recognizes are:

- JPG – raster
- PNG – raster
- PDF – raster or vector, depending on how it was created
- SVG - vector

There is an advantage to creating a file in outside design software and then saving that file as a vector file for loading into the Glowforge interface. It's much easier to align parts of the design first, and the relationship between the parts of the design will always stay the same.

For instance, if you want to cut out around an engraved image, if you create a file that has the image in it, with a cutline around it, then the engraving will always be centered relative to the cut line. The same thing happens for text. When you place it in a certain spot, it always stays there. If you group the parts of the design together, you can move that design anywhere around on the material – wherever you have space to cut and engrave it, and it will come out looking the same each time.

(It is also probably going to be a little more accurate than attempting to line it up visually using the camera.)

There are additional demos and tutorials available to explain more about how to set up files in various design software for use in the Glowforge interface. This is just an overview to start getting you familiar with the terms.

There are a lot of very handy and easy to use tutorials in the Matrix located in the Table of Contents of the Tips and Tricks section. <https://community.glowforge.com/t/community-glowforge-tutorials-table-of-contents/7339?u=jules>