Protohaven

Class Notes

Laser 114: Custom Wood Boxes

Clearances

Rabbit Large Format Laser

Contents

Welcome

Welcome to the Laser Box Making class at Protohaven!

Shop Rules

Be Safe

- Get safety clearances
- Wear protective equipment
- Watch and reset equipment after use
- Never use equipment that is red-tagged

Take Care of Each Other

- Be aware of your surroundings
- Don’t use a tool if it poses a danger to someone else

Take Care of the Tools

- Get tool clearances
- Do not alter of use equipment beyond limits
- Notify staff when maintenance is needed

Keep the Shop Clean

- Clean up after yourself
- Return tools to their original locations

Tool Status Tags

Every tool at Protohaven has a status to let you know if the tool is safe to use: green, yellow, or red.

If the tool status is *green*, the tool is safe to use. All features should be expected to work, and no extra care should need to be taken while using the tool. There are no tags for tools with green status.

If the tool status is *yellow*, the tool may still be used, but with extra caution. Tools with yellow status should have a physical tag on the machine. The information on the physical tag or in the online maintenance history will indicate what special care needs to be taken while using the tool. If the physical tag and the maintenance log disagree, alert a tech.

If the tool status is *red*: **DO NOT USE THE TOOL**. The tool is not safe to use. Tools with red status should have a physical tag on the machine. The information on the physical tag or in the online maintenance history will indicate what fixes are pending, and when a repair is expected.

If you are in doubt about the status of a tool with no visible tag, check the tool status by following the link in the QR code attached to the tool, or check the Protohaven website for the tool status page:

`https://www.protohaven.org/equipment/`

Filing a Tool Report

If you are using a tool, and the tool becomes unsafe, damaged, or is not working properly, you must notify a tech. The tech may instruct you to submit a tool report:

`https://airtable.com/appbIlORlmbIxNU1L/shrluff2WSzy8c3xd`

Notifying the tech will help us keep signage up to date, and make sure the users who come in after you have all the information they need to use the tool safely, even if they don't use discord.

Introduction

This class is an introduction to the large format lasers, with a focus on a box-making project.

With the right project file, we can laser-cut the parts of a box that use finger joints to fit together. Because the laser is so precise, we can tune the cut to make tight, strong joints.

Learning Objectives

After this class, you will be able to:

- Set up and safely operate the large format lasers
- Use LightBurn software to load and control a job
- Handle emergency situations
- Choose appropriate materials for your projects
- Make and assemble a box

Class Safety

Large format laser cutters use a very power laser to precisely cut and etch material on the laser bed. The lasers generate enough heat to create a fire risk with some materials, and some materials by release fumes when cut or etched.

Never leave a job running unattended: always be ready to stop the laser if something goes wrong.

If you feel unsure of something, feel free to ask!

Terminology

Making a Box

Overview

For this project, we will:

1. Set up a project template
2. Download the project file
3. Set up the material in the large format laser
4. Load and run the job
5. Assemble the box
6. Clean up

Set Up a Project Template

There are lots of online tools for generating project files that assemble into boxes. These tools allow us to customize the size, shape, and features of the box we want to make.

For this class, we will be using the web version of Florian Festi's `boxes.py` tool, hosted by the Bamberg Hackerspace:

`https://boxes.hackerspace-bamberg.de/?language=en`

First, select a project you would like to make on the large format laser (there are a lot!). Click the project icon to get to the setting page for that project.

The settings will vary depending on project. Some common settings that you should set (or check):

- The *dimensions* of the project can be altered to make a box that fits your needs.
- The *thickness* setting should be the same as the thickness of the material you are cutting.
- The *format* should be SVG.
- The *burn* setting may need to be adjusted for better fit.

Depending on the project, there may be other options you will want to adjust:

- There may be extensive settings for the *finger joints* - smaller finger joints may make a stronger join, but will increase job time.
- There may be additional features that can be added, like lids, handles, etc.

You can preview the project file by clicking the **Generate** button. Take a look at the project file and make sure nothing is off (no dimension is way out of spec, etc.)

Download the Project File

When you are happy with the project file, click the **Download** button. This will save your project file to local disk.

Set Up the Material in the Large Format Laser

To use the project file, we must transfer it to the desktop computer dedicated to the large format laser we want to use.

The easiest way to transfer the file is with a USB memory stick:

1. Copy your project file to a memory stick.
2. Safely eject the memory stick.
3. Insert the memory stick into one of the large format laser computers.
4. Copy the project file from the memory stick onto the local drive.
5. Safely eject the memory stick.

Load and Run the Job

With the project file on the local disk, follow the steps in

Follow the steps in Basic Operation to set up and run the large format laser.

Assemble the box

Once you have your project pieces, assemble them into your new box!

You may need to put the pieces together in a specific order.

If the fit is too tight, try gently removing material with sandpaper to improve the fit, or gently tapping on the parts with a rubber mallet to coax the pieces together.

Clean up

Cleaning up is an important step! We want to make sure the area is clean and free of debris for the people who want to use the laser next.

- Make sure that there are no cutouts stuck on the honeycomb and the bed is free of dust.
- Put reusable scrap in the scrap bins, and throw out all other debris into the studio garbage cans.
- If you want to keep your project file, make sure you transfer it to a personal USB drive.

Tools

Large Format Laser

The Large Format Laser can etch or cut various materials with precision.

Notes

Safety

Do not leave the laser running unattended. Lasers can cause fires. If your workpiece catches fire and the fire is not handled promptly, the fire can get out of control, and create an extreme hazard. Always keep watch over your running job, and be ready to extinguish any small fires with the nearby spray bottle, and/or hit the emergency stop if the laser goes out of control.

Keep the laser door closed during normal operation. The door protects those nearby from any possible eye damage or skin burns should the laser hit any reflective material.

Make sure the fan is running before cutting or etching. Running the laser on certain materials can produce gasses and make the studio environment unpleasant: the fans will pull the gasses outside.

Common Hazards

Some materials may heat up enough from the laser to catch fire. In case of a small fire, use the water spray bottles to quickly douse any small flames.

Some materials may produce toxic gas when cut or etched. Make sure the material you are cutting or etching is not listed in the Prohibited Materials subsection.

Depending on the material, laser cutting may produce sharp edges. Always handle materials carefully after they have been cut.

Care

Use care when opening and closing the cover; do not let the cover slam closed. The shock of letting the cover fall freely onto the chassis can damage the laser tube.

Materials

Protohaven carries a small selection of acrylic and plywood sheets for use with the large format lasers.

A list of Sources for Materials is included in the References section.

Prohibited Materials
Some materials are dangerous to etch or cut in the laser cutter: the process may cause a fire hazard, or introduce dangerous gasses into the studio space.

The following materials are prohibited for use in the laser cutter:

Prohibited Material	**Hazard**
Any material containing a halogen	Contains fluorine, chlorine, bromine, etc...
Artificial Leather	
AVS	Emits cynaide gas, melts, bursts into flame.
Butadiene-acrylonitrile Rubber	
Chlorinated Plastics	Emits chlorine gas.
Carbon Fiber, coated	Emits dangerous fumes.
Dry Moly Lube	
Easyweed Electric Heat Transfer Film	Contains polyurethanes.
Epoxy Resin	Emits formaldehyde and Hydrogen Cyanide.
Fiberglass	Emits dangerous fumes.
Foam Core	Extreme fire risk.
Foamular Extruded Polystyrene Insulation	
Galvanized Metal	Emits dangerous fumes.
HDPE	Catches fire and melts.
Laser Rubber	Emits hydrogen cyanide.
Lexan	May catch fire
Mirrored Surfaces	Will not cut, reflects laser beam.
Moleskine Notebooks	
Neoprene	
Nylon	
Oracal 651	Contains PVC, lead, chromium
Polycarbonate	May catch fire.
Polymer Clay	
Polypropylene	Catches fire.
Polyurethane	
Wood, Pressure Treated	Emits dangerous fumes.
PTFE	
PVC	
Rock Salt/Table Salt	Contains chlorine.
Sculpey	
Silicone conformal coating spray from MG Chemicals	Contains halogens.
Siser P.S. Film	Contains polyurethanes.
Siser StripFlock P.S. Film	Contains PVC.
Spandex & Stretch	Contains polyurethane.
Speedball Art Speedy Cut, Speedy Cut Easy and Speedy Carve	Contains PVC (at minimum).
Styrofoam	
Teflon	
Uncured Powder Coating	
Vinyl	

Approved Materials

Approved Material	Cut	Etch	Warning
3M 200MP Adhesive Transfer Tapes	✓	✓	
Abalone Shell	✓	✓	
Acrylic (1/8 inch)	✓	✓	Mirrored Acrylic reflective side down
Acrylic (1/4 inch)	✓	✓	Mirrored Acrylic reflective side down
Bamboo (1/8 inch)	✓	✓	
Battleship Linoleum	✓	✓	
Birch Plywood (1/4 inch)	✓	✓	
Birch Plywood (1/8 inch)	✓	✓	
Cardboard (1/8 inch)	✓	✓	
Cardstock (thick)	✓	✓	
Cellulose Acetate Butyrate	✓	✓	
Ceramic		✓	
Ceremark Metal Marking Compound		✓	
Chipboard (1/16 inch)	✓	✓	
Chipboard (3-ply)	✓	✓	
CobalTex RF	✓	✓	wash hands after handling the cut edges of this fabric to help prevent ingesting the metal dust
Corian	✓	✓	
Cork (natural fabric)	✓	✓	Only cork without adhesive backing. All artificial cork must be approved separately.
Cork (natural)	✓	✓	Only cork without adhesive backing. All artificial cork must be approved separately.
Coroplast Brand Corregated Polypropylene	✓	✓	watch for melting; bulk polypropylene is not approved
Cotton	✓	✓	Watch for fire.
Cotton Denim	✓	✓	Stretch denim has Spandex and is prohibited.
Delrin	✓	✓	
Depron Foam	✓	✓	
Easyweed Glow in the Dark Heat Transfer Film	✓	✓	
Eco-fi™ Specialty Craft Felts	✓	✓	
EVA copolymer (5mm)	✓	✓	
Felt (1/8 inch)	✓	✓	Watch for fire.
Formica (1/32 inch)	✓	✓	
Freezer Paper	✓	✓	Raw polyethylene is not approved
GE Silicone Caulk	✓	✓	
Glass		✓	
Hemp	✓	✓	Watch for fire.
Kaolin Clay (claybord)	✓	✓	

Approved Material	Cut	Etch	Warning
Kapton Film	✓	✓	FPC and HN variants only
LDF	✓	✓	
Leather (natural 1.5-2.0mm)	✓	✓	Only use natural leather.
Leather (natural 1/8 inch)	✓	✓	Only use natural leather.
Magnetic Sheets	✓	✓	
Marmoleum	✓	✓	
Masonite	✓	✓	
MDF (1/4 inch)	✓	✓	
Metal (painted/anodized)		✓	The laser must not be used over 50% power in this scenario. Reflections can damage the optics.
ModPodge Gloss	✓	✓	
Mylar	✓	✓	
Mylar (10 mil sheet)	✓		
Non-Chlorinated Rubber	✓	✓	
Painter's Tape	✓	✓	
Paints and Thin Spray Coatings (thinner than powder coating)		✓	
Paper	✓	✓	
Peelable Solder Mask (latex)	✓	✓	
PET Plastic	✓	✓	
PETG Plastic	✓	✓	
PLA Plastic	✓	✓	
Plaster of Paris		✓	
Plasti-dip		✓	
Plexiglass (1/4 inch)	✓	✓	
Plywood (1/16 inch)	✓	✓	
Plywood (1/4 inch)	✓	✓	
Plywood (1/8 inch)	✓	✓	
Polybutylene Terephthalate	✓	✓	Must not contain brominated fire retardant
Polypropylene Tape	✓	✓	
Polystyrene	✓	✓	Watch for fire.
Rowmark LaserMAX	✓	✓	
Siser Glitter Heat Transfer Film	✓	✓	
Speedball Art Linoleum	✓	✓	
Stone		✓	
Suede	✓	✓	
Wood	✓	✓	
Wool	✓	✓	Watch for fire.
Worbla BlackArt	✓	✓	
Worbla FinestArt	✓	✓	
Worbla TranspArt	✓	✓	

Parts of the Laser Cutter

Front Quarter View

Figure 1: Annotated front-quarter view of the large format laser.

Control Panel

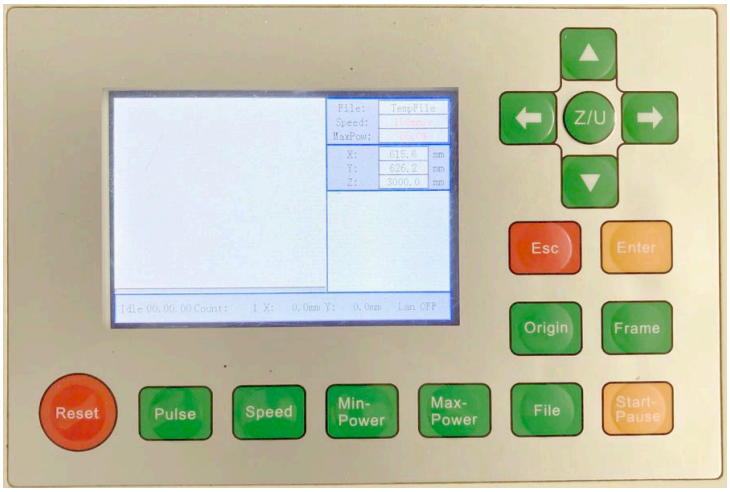

Figure 2: The control panel for the large format laser in the default view.

On/Off Switch

Turn the key to the right (clockwise) to power on the laser.

Turn the key to the left (counter-clockwise) to power off the laser.

Emergency Stop Switch

Press the emergency stop switch to power off the laser.

To re-enable the laser, pull up on the emergency stop button while twisting clockwise.

Lid

The lid must be closed for the laser to fire.

Always close the lid gently to avoid damaging the laser tube.

Check to make sure that nothing is in the way (pieces of paper, material scraps, etc.) that may keep the lid open and interrupt the laser.

Lens Carriage

The lens carriage moves the laser over the workpiece during a cut.

Bed

The bed supports the workpiece. The bed can be raised and lowered to adjust the focus of the laser.

Control Panel

Use the control panel to adjust the bed and lens carriage, set the origin, and other functions.

Many functions can also be used through LightBurn.

Spray Bottle

A spray bottle filled with water is kep on the right side of the cabinet. Use the spray bottle to quickly douse small material fires.

Magnets

A collection of magnets are kept on the left side of the cabinet. Use these magnets to anchor the workpiece to the bed.

Basic Operation

1. Set Up the Laser
2. Workholding
3. Focus the Lens
4. Set the Origin
5. Set up the Job in LightBurn
6. Run the Job on the Laser
7. Cleaning Up

Set Up the Laser

1. Turn on the large format laser.
2. Make sure chiller is powered on and working.
   Look for the green status light on the front of the chiller.
3. Make sure the exhaust fan is running.
4. Carefully open the lid.
   The lid is heavy; letting the lid slam closed will damage the laser.
5. Secure the workpiece to the grid.
   use the provided mounting magnets to hold the workpiece in place.
6. Position the laser head over the workpiece.
   Use the directional buttons to move the laser head across the bed.

Workholding

Use magnets to secure the workpiece to the grid.

Make sure that the laser's path won't cause the laser to cut the magnets, or for the laser head to crash into the magnets.

Focus the Lens

Use a focus block on the workpiece to set the height of the lens and bring it into focus.

1. Press the **Z/U** button to change to bed height control.
   *The screen will display a menu with **Z move** highlighted in blue.*
2. Press the ← (right arrow) and → (left arrow) buttons to align the focus gauge to the second ring of the lens carriage.
   The right arrow lowers the bed, and the left arrow raises the bed.
3. Press the **Esc** button to return to the main screen.

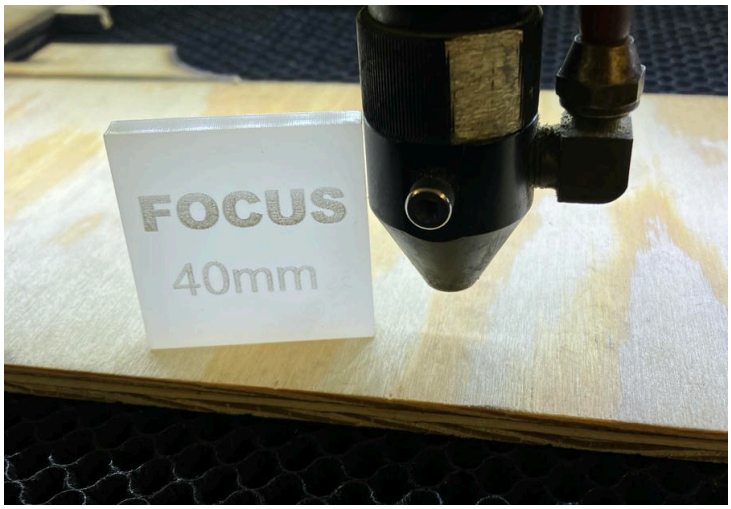

Figure 3: Lens carriage aligned with the focus gauge (40mm).

Set the Origin

1. Position the laser head over the workpiece at the location you want to set as a boundry for your art.
   Use the directional buttons to move the laser head across the bed.

- *Optional:* Press the **Pulse** button to verify the exact location.

2. Press the **Origin** button to set the origin point for the job.

Set up the Job in LightBurn

These steps detail loading a single vector art file into LightBurn, and using that file to run a job with the laser. LightBurn is capable of much more: with LightBurn, we can load, manipulate, and compose multiple images into one job. For more about LightBurn, please see LightBurn.

Import the Art

1. Open LightBurn on the computer connected to the large format laser.

2. Click **File > Import**.
3. Select the art file to import.

The art will be automatically placed on the LightBurn canvas. You may need to zoom and/or pan the view to see all of the art.

(Optional) Manipulate the Art
LightBurn is a capable image editor, and has many features that a specific to preparing artwork for the laser.

Work that is commonly done in LightBurn prior to cutting or etching:

- Duplicating the art to cut multiple copies.
- Putting portions of the art into layers, for different cuts and/or ordering the cuts.

Set the Reference Origin
Set the reference origin in LightBurn with the Job Origin tool:

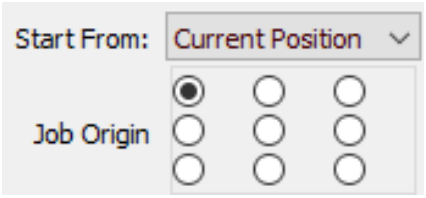

Figure 4: The Job Origin tool, currently set with the origin at the upper left.

Set the Speed and Power
In the **Cuts/Layers** panel, each layer will have a listed speed and power in the **Spd/Pwr** column.

These settings must be adjusted for the material (wood, acrylic, natural leather) and purpose (cutting or etching). To adjust the speed and power settings:

1. Click on the value in this column to bring up the **Cut Settings Editor** dialog box.

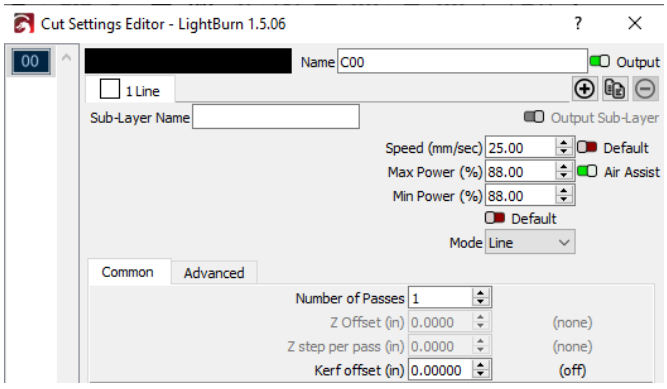

Figure 5: The top half of the Cut Settings Editor dialog box.

2. Use this dialog box to adjust the **Speed** and **Max Power** settings for the cut.
3. Click **OK**.

See Speed and Power Settings For Common Materials for good starting speed and power values for materials.

Run the Job on the Laser

1. Check the footprint of your job.
   *In LightBurn, press the Rectangular **Frame** button to command the laser to trace out the box boundary of the job, or the Circular **Frame** button to trace out the exact boundary of the job. The laser will trace out the area of the job. Make sure that the traced path does not leave the media, or run over any of the hold-down magnets.*
2. Press the start button.
3. Monitor the machine until the job is complete.
   While the job is running, remain nearby the laser to make sure nothing goes wrong.

Cleaning Up

1. Power off the Laser.
2. Reset any modified computer settings to default.
3. Vacuum the interior so material does not build up beneath the honeycomb.
4. Recycle waste in the single-stream scrap bins.

Report any maintenance needs or concerns at protohaven.org/maintenance, or by alerting a shop tech on duty.

If the single-stream scrap bins become full, alert a shop tech.

Reference

Speed and Power Settings For Common Materials

Approved Material	Cut Speed (mm/s)	Cut Power (%)	Cut Passes	Etch Speed (mm/s)	Etch Power (%)
Acrylic (1/8 inch)	25	85	2	350	60
Acrylic (1/4 inch)	15	85	2	350	60
Bamboo (1/8 inch)	22	85	1	350	30
Battleship Linoleum	20	85	2-3	300	50
Birch Plywood (1/4 inch)	15	85	?	350	30
Birch Plywood (1/8 inch)	25	88	?	350	30
Cardboard (1/8 inch)	100	35	?	350	25
Cardstock (thick)	300	25	1	350	15
Chipboard (1/16 inch)	175	65	1	350	30
Chipboard (3-ply)	30	90	?	350	30
Cork (natural fabric)	100	75	1	350	25
EVA copolymer (5mm)	100	55	1	350	15
Felt (1/8 inch)	100	65	1	350	25
Formica (1/32 inch)	25	85	1	350	40
Leather (natural 1.5-2.0mm)	25	85	1	300	25
Leather (natural 1/8 inch)	25	85	1	300	25
Masonite	25	85	?	350	30
MDF (1/4 inch)	11	90	2	350	35
Plexiglass (1/4 inch)	20	85	2	350	65

Approved Material	Cut Speed (mm/s)	Cut Power (%)	Cut Passes	Etch Speed (mm/s)	Etch Power (%)
Plywood (1/16 inch)	50	65	?	350	35
Plywood (1/4 inch)	13	90	1	350	35
Plywood (1/8 inch)	25	85	1	350	35
Rowmark LaserMAX	11	85	?	350	24

Sources for Materials

A small selection of acrylic and plywood is available for purchase at the Protohaven shop.

Approved Material	Sources
Acrylic (1/8 inch)	https://www.amazon.com/acrylic-sheet/s?k=acrylic+sheet
Acrylic (1/4 inch)	https://www.amazon.com/acrylic-sheet/s?k=acrylic+sheet
Cellulose Acetate Butyrate	https://www.chempoint.com/products/eastman/eastman-cellulose-esters/cellulose-acetate-butyrate/cab-171-15
Ceremark Metal Marking Compound	https://www.cermarkusa.com/
Chipboard (1/16 inch)	https://www.dickblick.com/products/all-purpose-chipboard/
Chipboard (3-ply)	https://www.dickblick.com/products/all-purpose-chipboard/
CobalTex RF	https://lessemf.com/product/cobaltex-fabric/
Freezer Paper	https://www.amazon.com/Reynolds-Kitchens-Freezer-Paper-Square/dp/B000BZYCNK
ModPodge Gloss	https://www.michaels.com/mod-podge-gloss/M10047536.html
Painter's Tape	https://www.amazon.com/ScotchBlueTM-Painters-Tape-Core-Yd/dp/B00004Z4DU
Plexiglass (1/4 inch)	https://www.amazon.com/Source-Thick-Inches-Acrylic-Plexiglass/dp/B004DYW31I
Plywood (1/16 inch)	https://ocoochhardwoods.com/plywood/baltic-birch-plywood/
Plywood (1/4 inch)	https://ocoochhardwoods.com/plywood/baltic-birch-plywood/
Plywood (1/8 inch)	https://ocoochhardwoods.com/plywood/baltic-birch-plywood/

Software

Inkscape

Inkscape is software for creating and editing vector graphics:

`https://inkscape.org/`

Inkscape is a valuable tool that's useful in many parts of the shop.

A common use of Inkscape is to prepare art for import into the software that drives various tools around the shop. Protohaven members use Inkscape to create and edit designs for use with:

- Large Format Laser (LightBurn)
- CNC Embroidery (Artistic Designer)
- Vinyl Cutter (Sure Cuts A-Lot)
- CNC Router (Vcarve)

Inkscape can be used to prepare art for the Large Format Printer.

Inkscape is also a good general purpose tool for creating visuals: drawings, infographics, logos, title blocks, icons.

Download

Inkscape is freely available to download and use for Linux, Windows, and MacOS:

`https://inkscape.org/release/`

Help and Tutorials

Manual

The Inkscape project maintains a comprehensive manual:

`https://inkscape-manuals.readthedocs.io/en/latest/index.html`

The manual is updated regularly, and available for both online (HTML) and offline (PDF, ePub) reading.

Video

A short tutorial to get started with Inkscape:

- Inkscape Tutorial: Complete Starter Guide for New Users (with chapters)
  `https://www.youtube.com/watch?v=fzk-suGcqrc`

A comprehensive tutorial series for Inkscape is available from TJ Free:

`https://www.youtube.com/playlist?list=PLqazFFzUAPc5lOQwDoZ4Dw2YSXtO7lWNv`

Some videos from the series that are good places to start:

- Inkscape Lesson 1 - Interface and Basic Drawing
  `https://www.youtube.com/watch?v=8f011wdiW7g`
- Inkscape Lesson 10 - Trace Images with Bezier Tool
  `https://www.youtube.com/watch?v=sagrkdmC_BI`
- Inkscape Lesson 11 - Trace Bitmap Tool (Convert Raster to SVG)
  `https://www.youtube.com/watch?v=E7HwLTQu2FI`

LightBurn

LightBurn is layout, editing, and control software for the large format lasers:

`https://lightburnsoftware.com/`

LightBurn is only available on the desktops dedicated for use with the lasers.

LightBurn is capable of handling all stages of a laser project, from art design through to running the job on the laser.

LightBurn can also import vector and raster art from other sources: you can work on your project in other software and then import it into LightBurn when you're ready to run the job.

Help and Tutorials

LightBurn software has a YouTube page (`https://www.youtube.com/@lightburnsoftware7189/`) with lots of content to help with projects. For those new to laser cutting and etching, these videos are a good place to start:

- Getting Started With LightBurn: Set up & First Project
  `https://www.youtube.com/watch?v=v3RDzOrlCTM`
- LightBurn UI Walkthrough
  `https://www.youtube.com/watch?v=uzFsrUwONbw`
- LightBurn Cut Settings
  `https://www.youtube.com/watch?v=nybhYtjElQU`

Concepts

Image Types

For computers to work with image data, the image data needs to be *encoded* in some way so that the computer can understand it. There are many approaches to encoding visual data, but most of them fall into two categories:

- raster images, where the image is encoded as a grid of dots
- vector images, where the image is encoded as a collection of objects

Raster Images

Raster images are composed of lots of dots: a rectangular grid of points, each point encoded with color information. If we zoom way in on a raster image, we'll see that it's made up of this grid of dots. In the following image, we can see from the zoomed in portion of the image that it's made up of lots of tiny dots of color:

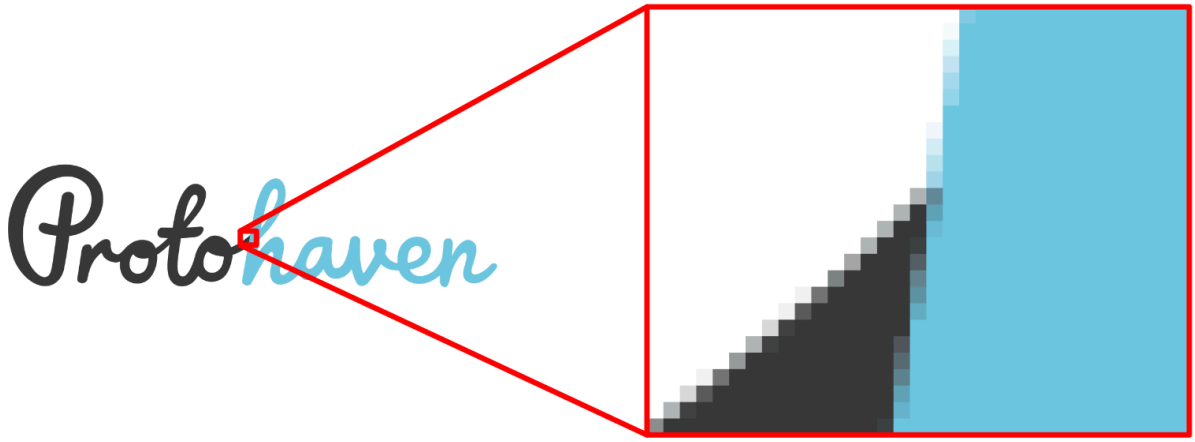

Figure 6: A small section of a raster image, magnified.

These dots are often referred to as *pixels*.

The number of pixels we have in an image partially determines its quality. The more dots in the image, the better the image will look (to a degree) and the more we'll be able to adapt it for a variety of uses: we can, for example, scale up an image with lots of pixels and still have it look reasonable for most applications.

Raster images are useful for rich graphics: photographs, non-technical line art, etc. Raster images are particularly good for photographic material.

Raster images are a poor choice for transmitting text (particularly if scaled), or vector art like line drawings, schematics, etc.

Common file formats like `.jpeg`, `.gif`, and `.png` are all image raster data.

Vector Images

Vector images are built from logical instructions. In a raster image, a line might be encoded as a string of dots on the grid. In a vector image, a line is encoded as a logical connection between two points. A nice property of vector images is that they scale very well: they can be re-rendered with precision at any size. In the following image, we can see in the zoomed in portion of the image that there is no loss in precision or quality of the image:

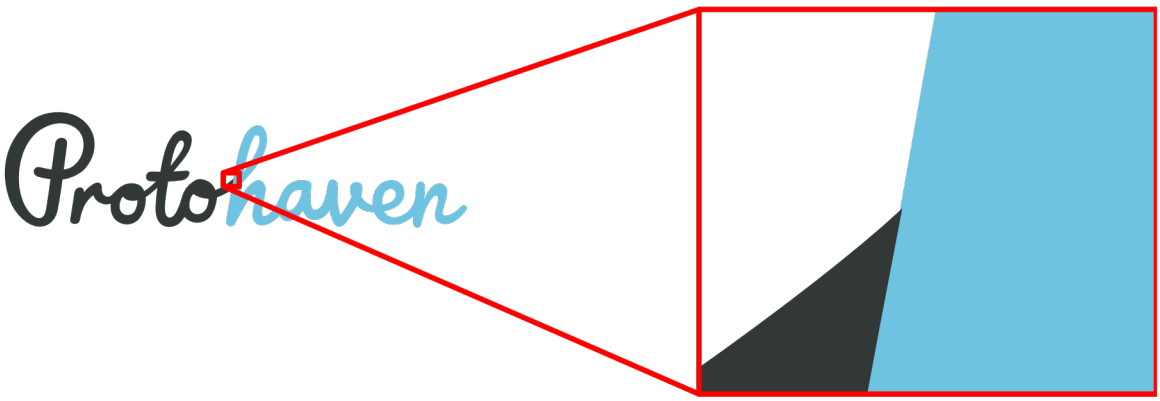

Figure 7: A small section of a vector image, magnified.

Vector graphics are made of *objects*.

The objects in a vector graphics file logically describe the visual contents of the file. For example, the file my specify that at a particular coordinate on the canvas there is a square, filled in with a particular color. The information is not encoded in dots, like a raster image: the image contents are described instead by a collection of objects that describe an image.

Vector graphics are useful for any image that requires precision: vector formats are good choices for infographics, technical line drawings, schematics, and similar art.

Vector graphics are also useful for any art that has a text component: labels, legends, titles, etc. With a vector graphic, the text is also stored as vectors (the glyphs of the font, or objects derived from it), and the image can be scaled without any loss of quality for the text or the art.

Common file formats like `.ai`, `.dxf`, and `.svg` are all image vector data.

Resources

Internet Forums

- https://forum.laseruser.com/
- https://sawmillcreek.org/forumdisplay.php?8-Laser-Engraving-General-Topics

Tools for Generating Projects

- https://makerdesignlab.com/tutorials-tips/online-file-generators-for-laser-cutting/