Bringing Frickin' Lasers to the San Diego Burning Man community

Sol Diego Laser @ Colab

Basic Operation and Safety Training Course 101

Bringing Frickin' Lasers to the San Diego Burning Man community

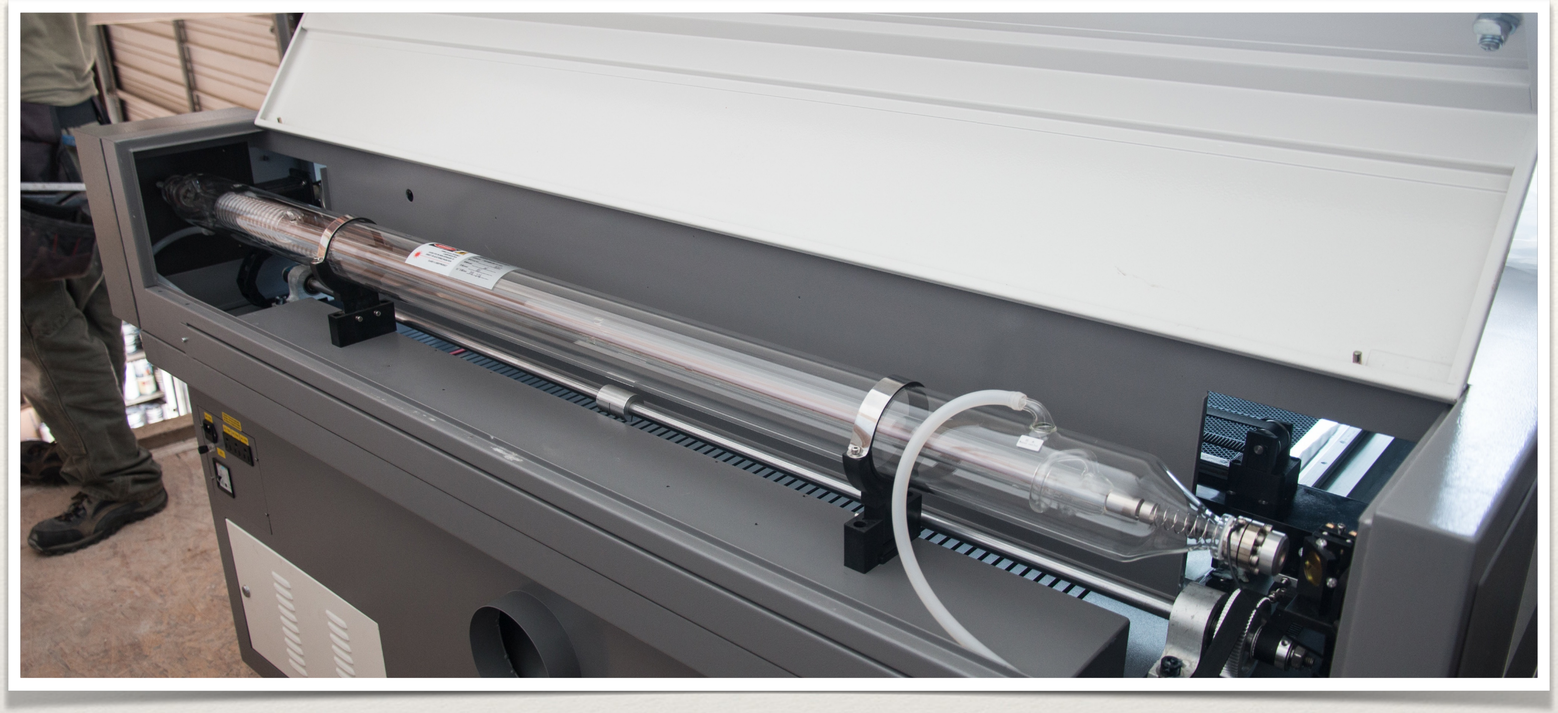
Sol Diego Laser @ Colab

Basic Operation and Safety Training Course 101

Course Overview



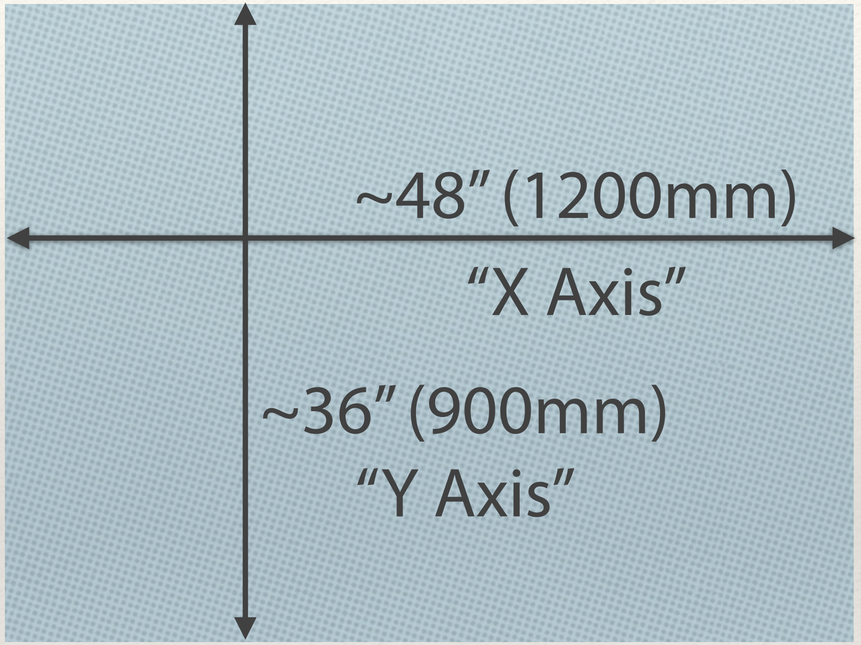
- What is the laser?
- What can it do?
- How can it hurt you?
- How to prepare a design
- How to execute a job
- Scheduling time on the laser



CO_2 Laser Tube

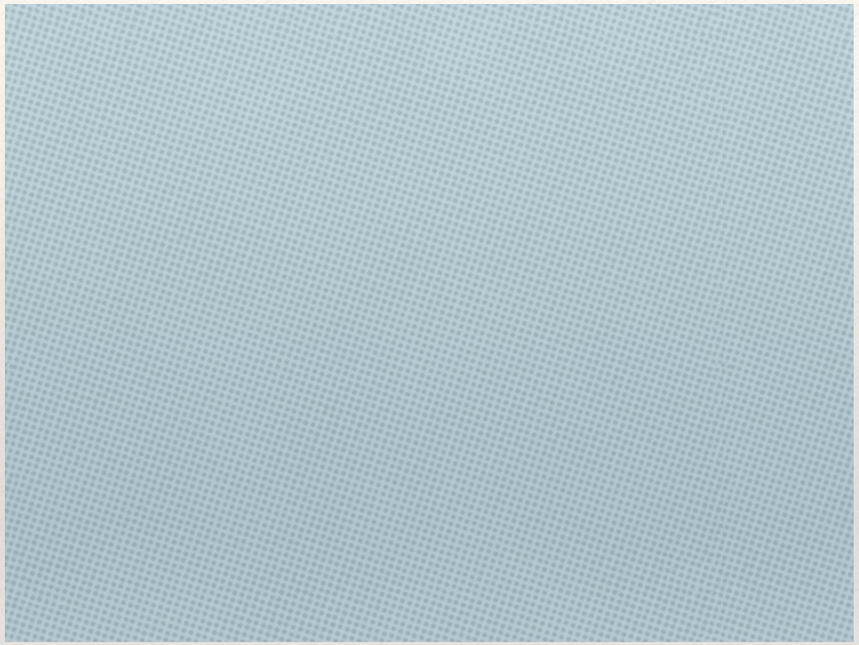
- up to 180 watts of infrared light (that's a lot if you focus it on a tiny point)
- tube emits a pencil-width beam, which is then focused on your work by a special lens
- infrared light is invisible; most materials are opaque
- requires high voltage and a flow of cooling water

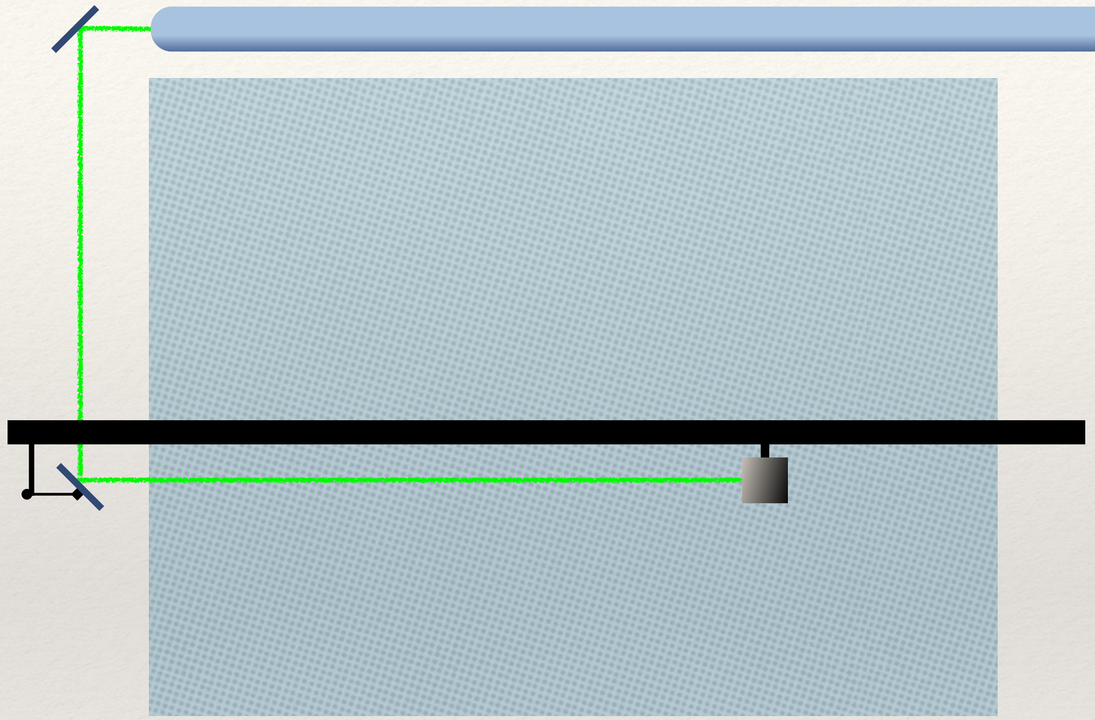
Our Laser Provides a Large Flat Workspace

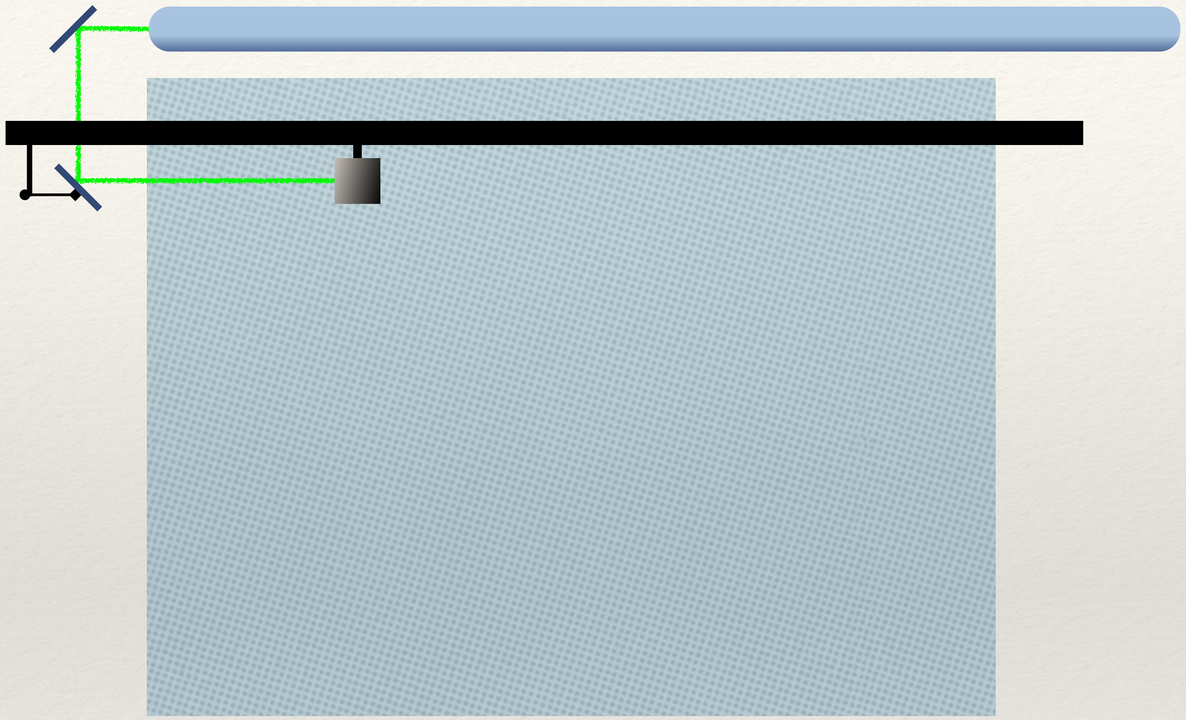


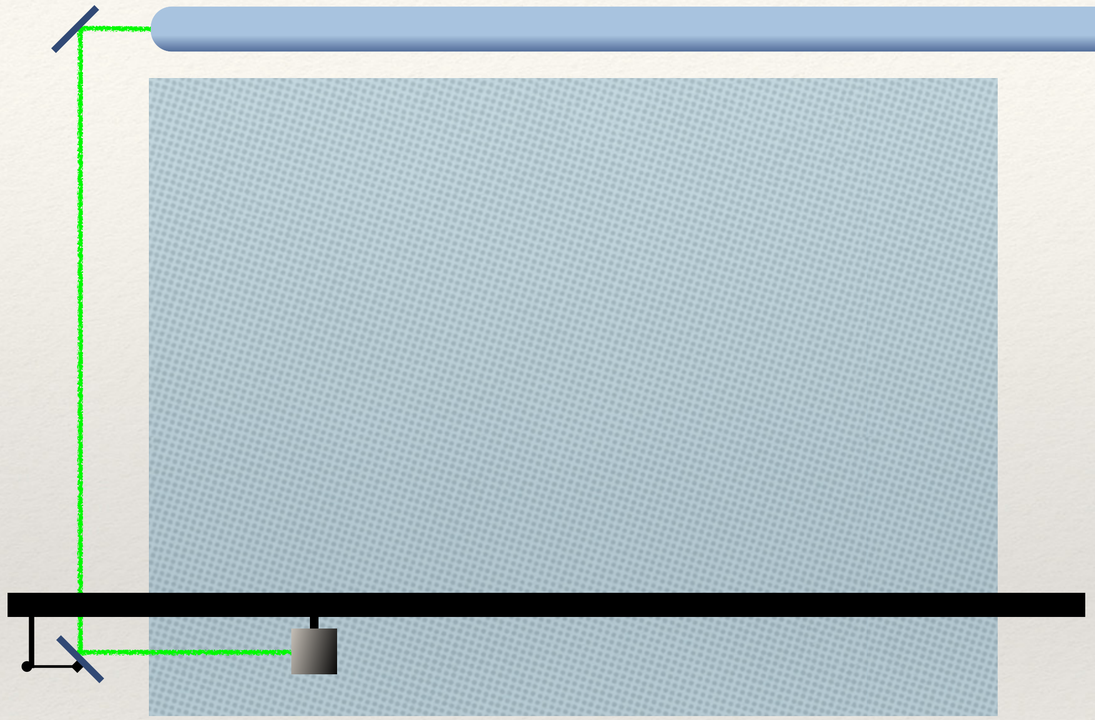
Laser tube is mounted horizontally behind the table

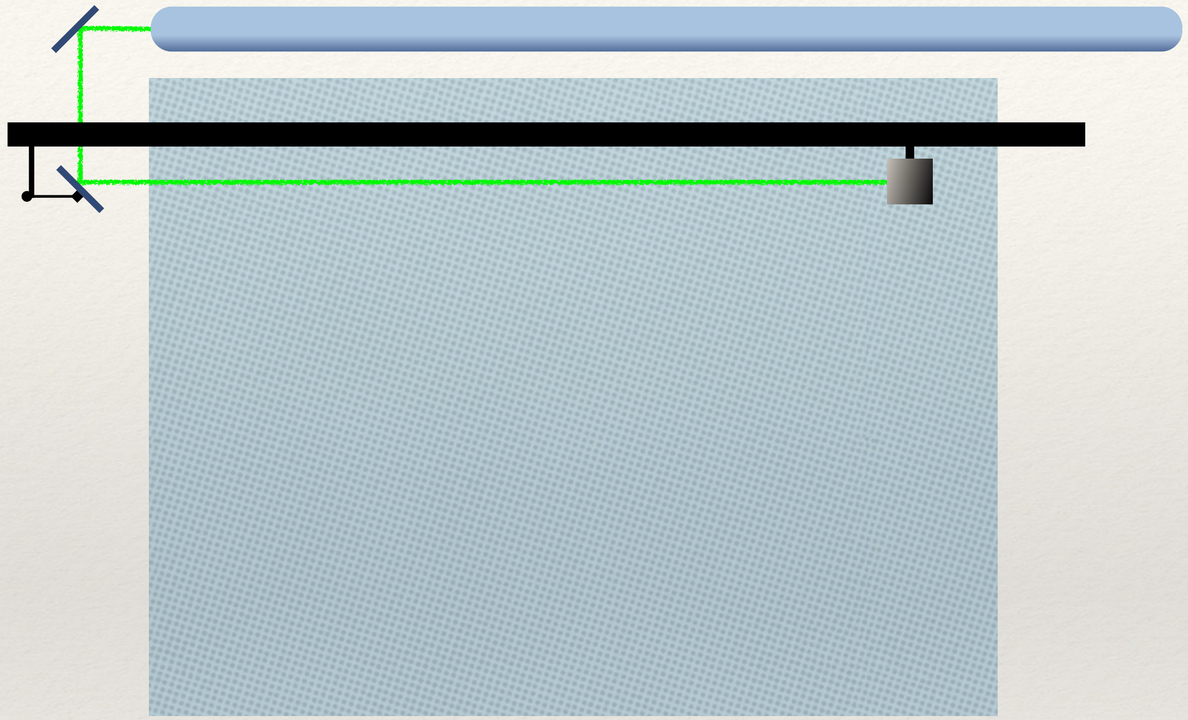
Green stands for the infrared laser beam (actually it's invisible)

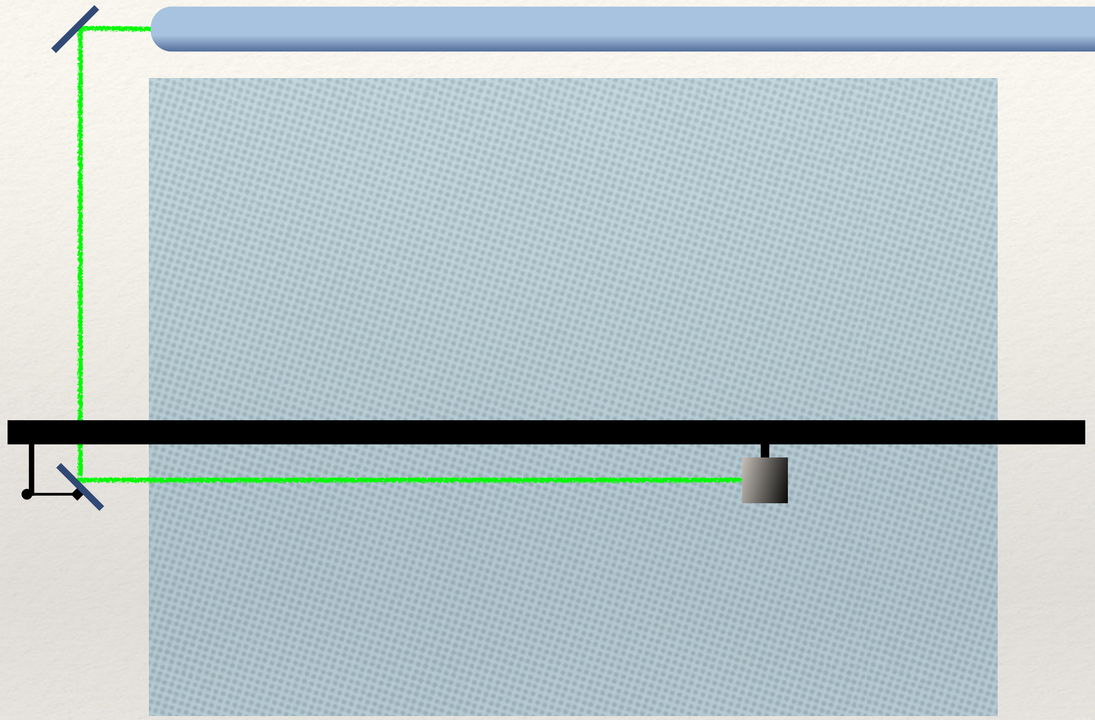




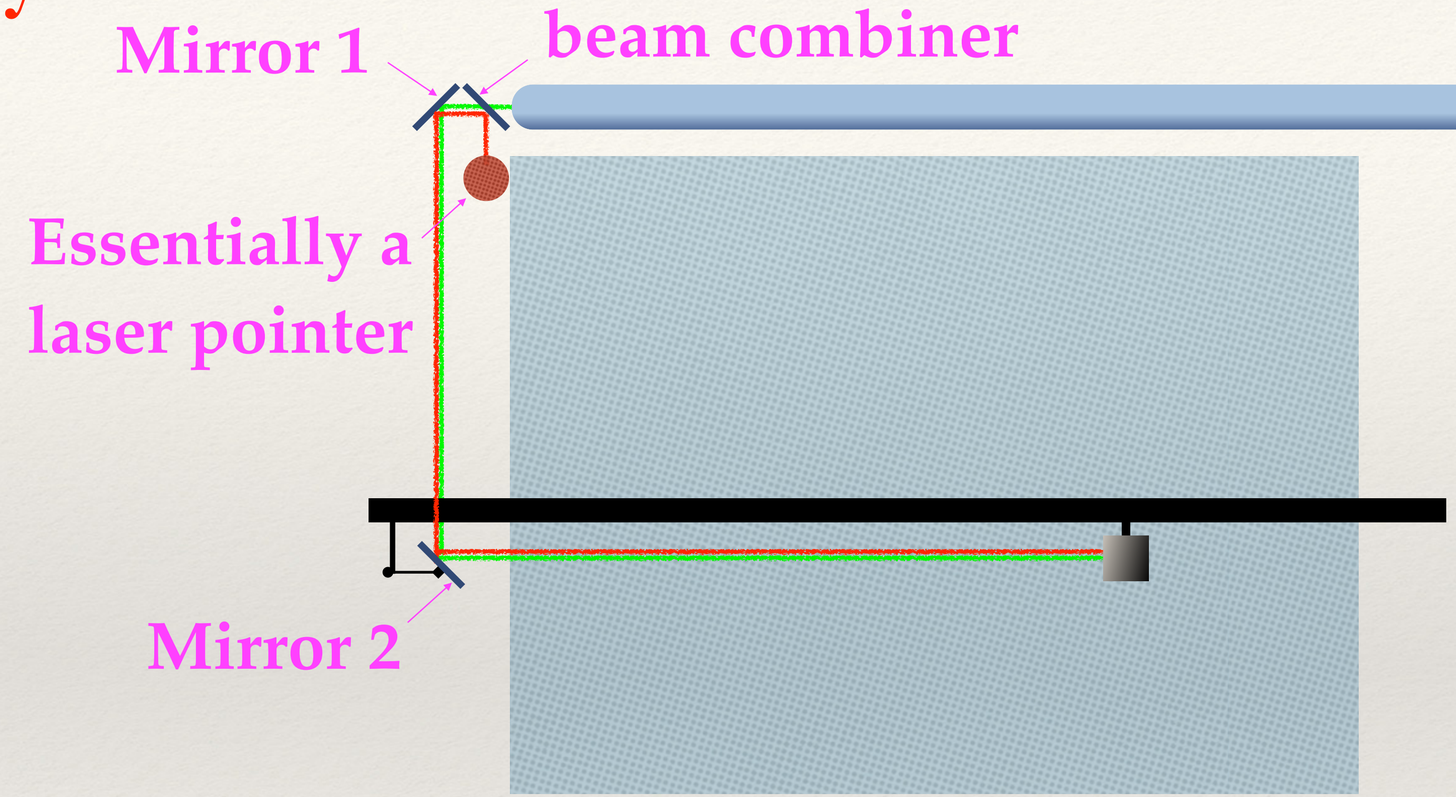


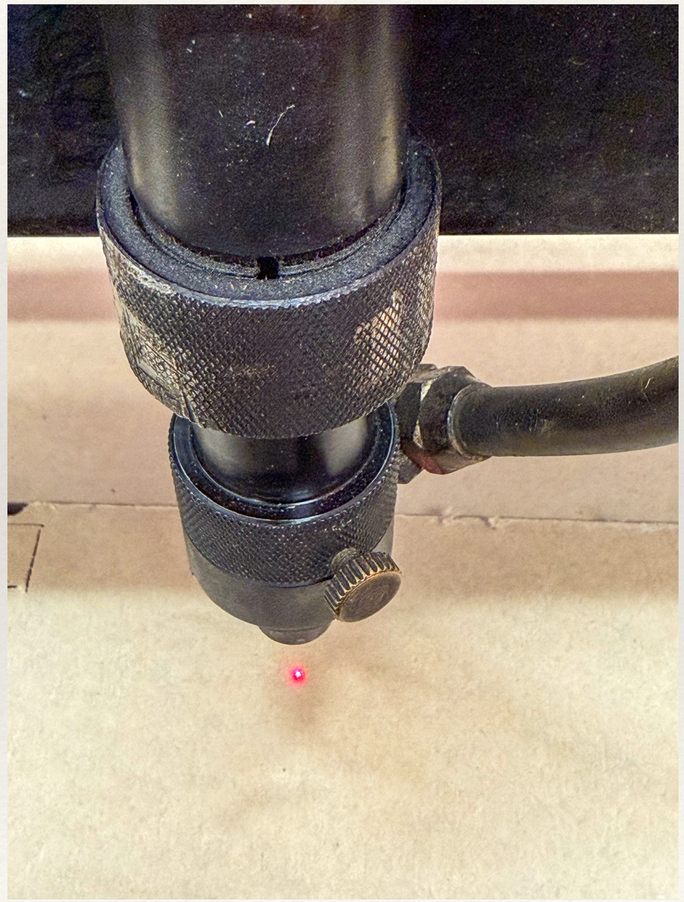






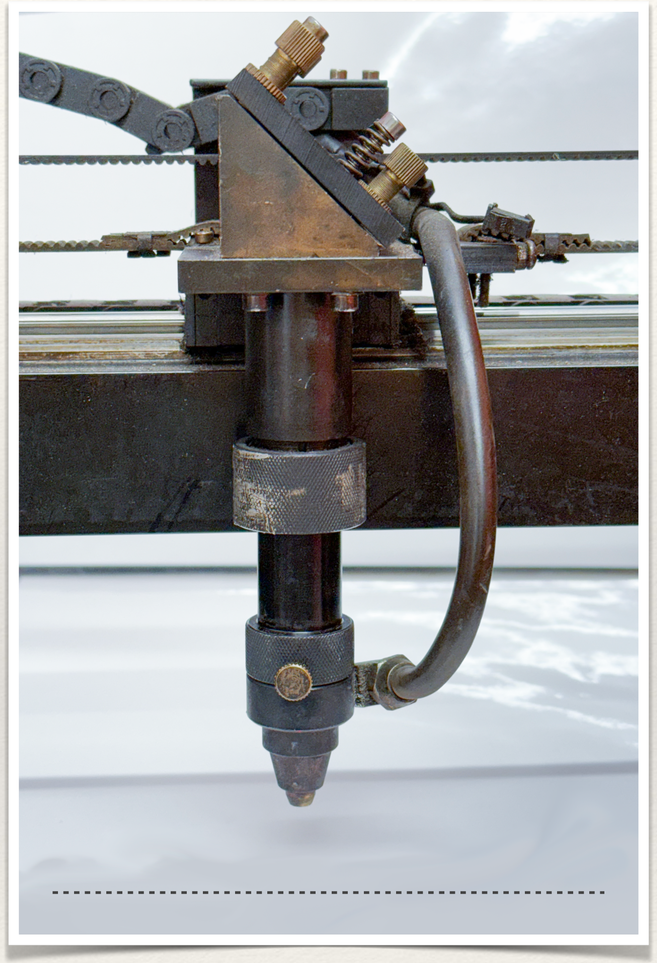
Always-on visible red laser follows “same” optical path





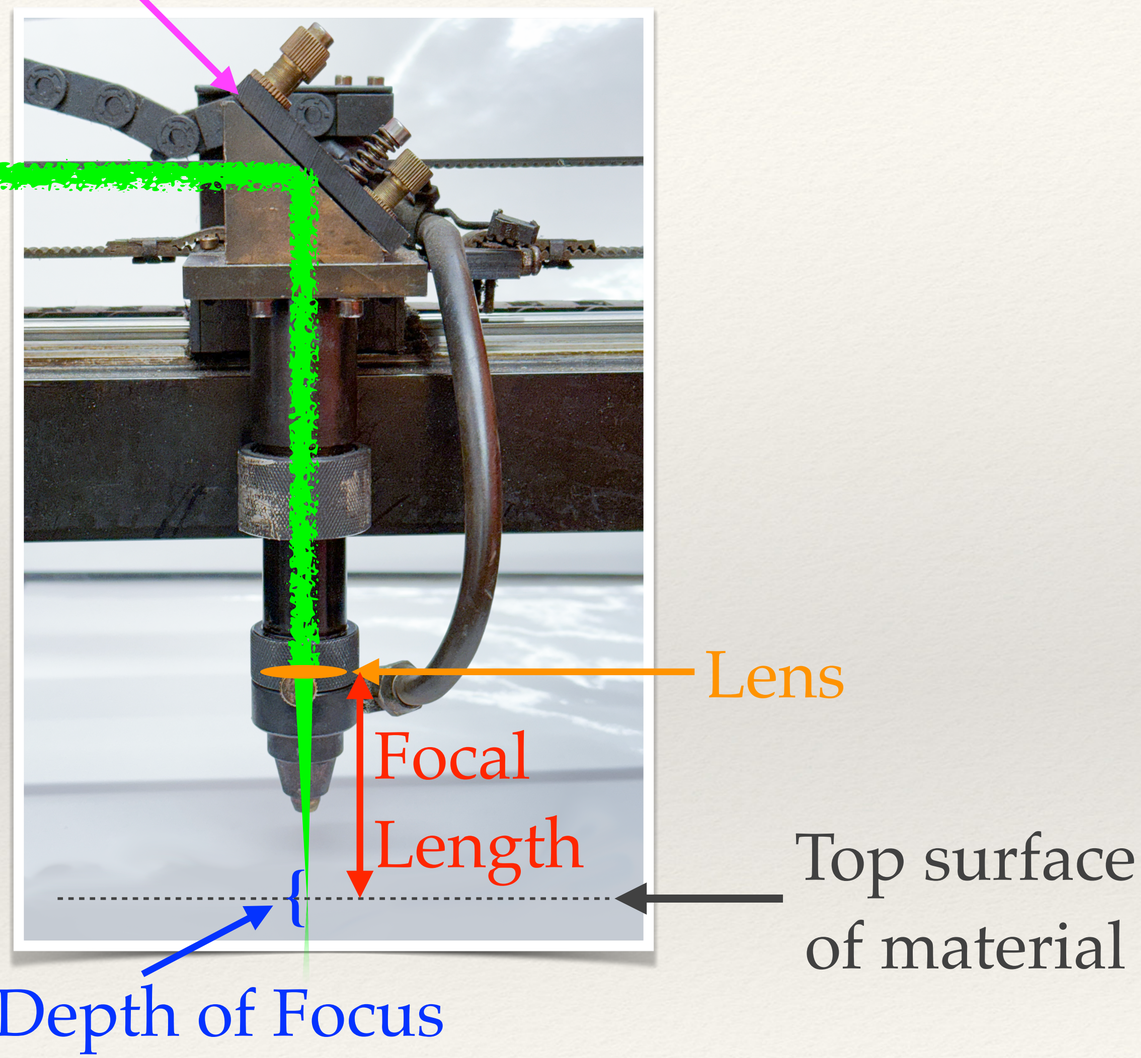
Business End

Or, the laser's *head*



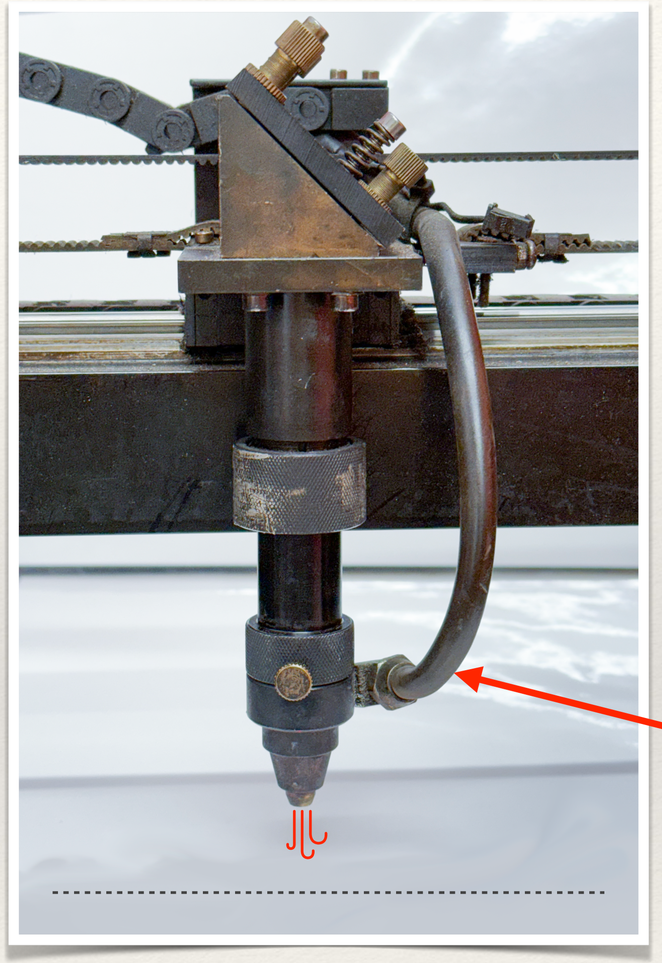
Business End

- Lens focuses the beam
- Usually focus on top surface of work
- Focus by moving table up and down ("Z axis")
- Laser is close enough to *in focus* over a narrow range of heights (~ ¼ inch) with standard 2.5" focal length lens



Business End

- Compressed air blows smoke and debris away from the work and keeps it (mostly) off the lens
- Called “air assist”
- Two speeds of air assist:
  - Low speed for engraving
  - High speed for cutting
  - Coming soon



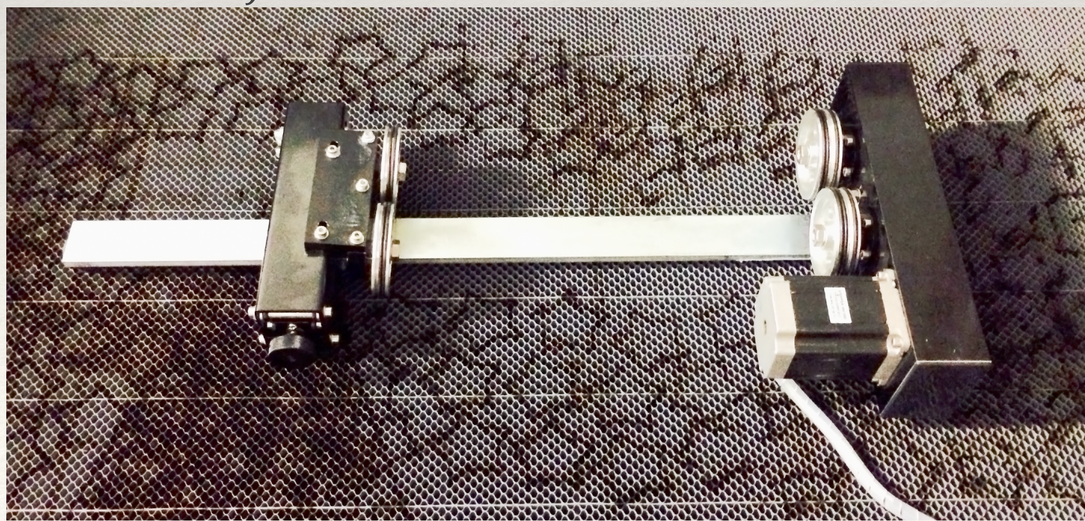
Escaping Flatland

- The X-Y gantry mechanism only covers a flat plane. Limited depth of focus means that the material must be pretty flat.
- Our laser is equipped with a motorized table that can move up and down: Z axis.
- Normally, this is a one-time setting that compensates for the thickness of the material. The material still has to be flat.
- But there's a way to get around that …

Rotary Adapters

- A rotary adapter replaces the Y axis gantry movement with rotation.
- The chuck adapter (left) can handle any cylindrical object that's small enough.
- The standard adapter (right) can be adjusted to handle tapered objects.





Main Laser Equipment

Water chiller:
Cool water runs through laser tube to prevent overheating. Turn on manually whenever laser is *powered on*.



On/off switch

Green light should be on (may be dim)

The Laser

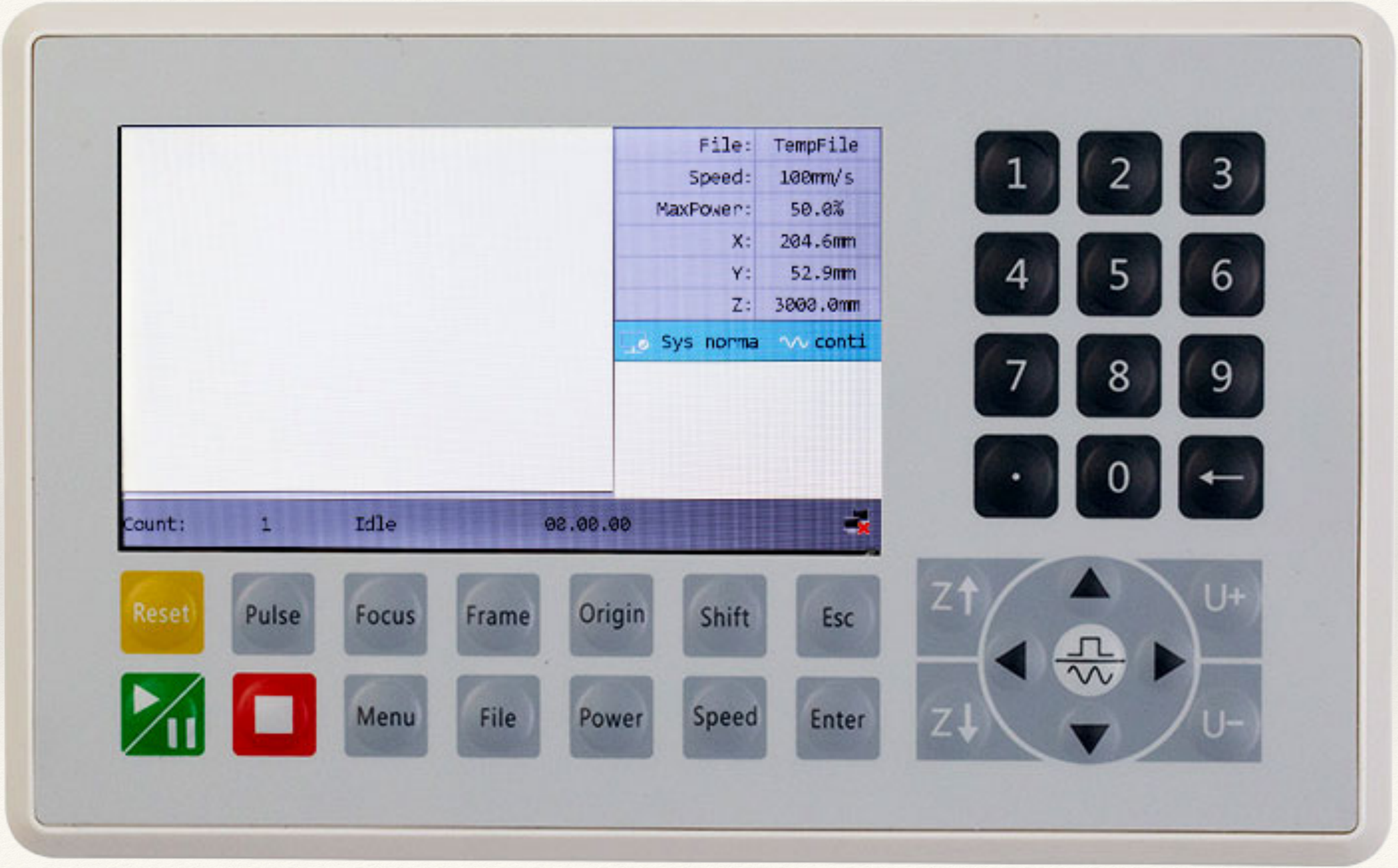




Exhaust fan (upstairs):
Removes smoke and fumes released from material by laser. Automatically turned on whenever laser is *powered on*.

"Air assist" compressor:
Blows air through laser nozzle. Automatically turned on whenever laser is *running*.




File: TempFile
Speed: 100mm/s
MaxPower: 50.0%
X: 204.6mm
Y: 52.9mm
Z: 3000.0mm
Sys norma
conti
Count: 1
Idle
00.00.00
1
2
3
4
5
6
7
8
9
.
0
←
Reset
Pulse
Focus
Frame
Origin
Shift
Esc
Menu
File
Power
Speed
Enter
Z↑
U+
Z↓
U-

What Can It Do?

- Laser delivers concentrated, controlled HEAT
  - Burns
  - Melts
  - Vaporizes
  - Shatters
- … depending on the material.

What Do YOU Control?

- **Where** the heat goes
- **How much** heat gets delivered:
  - laser output power
  - speed of head motion
  - number of passes
  - other less common settings
- **In what order** it gets delivered

How Do You Control It?

- *Where* is an X-Y location on a rectangle (the laser bed).
- You control *where* by drawing a picture (your design file).
- You can assign one of 30+2 colors to each item in your design. Each color or "*layer*" gets its own *settings* in the LightBurn software.
- LightBurn processes each layer all at once, in an order you control.

<untitled> * - Dummy Ruida - LightBurn Pro 2.0.01
XPos 221.648 mm
YPos 177.257 mm
Width 647.624 mm
Height 430.493 mm
100.000 %
Rotate 0.00
mm
Font Arial
Height 25.00
Bold
Italic
Upper Case
Distort
Welded
HSpace 0.00
VSpace 0.00
Align X Middle
Align Y Middle
Normal
Offset 0
Radius:
5.0
Cuts / Layers
Layer Mode Spd/Pwr Output Show Air
C00 00 Fill 100 / 20
C02 02 Line 100 / 20
Layer Color
Speed (mm/s) 100.00
Pass Count 1
Power Max (%) 20.00
Interval (mm) 0.100
Power Min (%) 20.00
Cuts / Layers
Camera Control
Variable Text
Move
Laser
Disconnected
Pause
Stop
Start
Send
Frame
Frame
Save RD file
Run RD file
Home
Go to Origin
Start From: Absolute Coords
Job Origin
Cut Selected Graphics
Show Last Position
Use Selection Origin
Optimization Settings
Devices
Dummy Ruida
Laser
Material Library
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 T1 T2
Move
Size
Rotate
Shear
x: 1,334.00, y: -12.00 mm

Do I Have To Use LightBurn?

- Yes, but …
- RDWorks is the controller's proprietary software. Try it if you want, but we don't support it. LightBurn is better.
- If you prefer to design using another vector drawing program, you can. Use LightBurn's color palette. Export to any common vector file format. Import that file into LightBurn and use LightBurn for laser-specific functions.

Can I Use LightBurn at Home?

- Yes, but …
- LightBurn costs money after a 30-day free trial. $99 for LightBurn Core, $199 for LightBurn Pro.
- We need LightBurn Pro at Colab to work with our laser, but you can do design work with the Core version.
- Needs Windows 10+ or macOS 11+ to run the latest version.

Learning LightBurn

- LightBurn is easy – *usually*
- LightBurn has lots of features for advanced needs. More than we can cover in this class.
  Learn them as you need them.
- LightBurn has really good documentation at docs.lightburnsoftware.com and in its Help menu.
- There are MANY MANY tutorials for LightBurn on the Internet, especially videos on YouTube.
  Search and ye shall find.

3 Ways to Map Your Design onto the Laser Bed

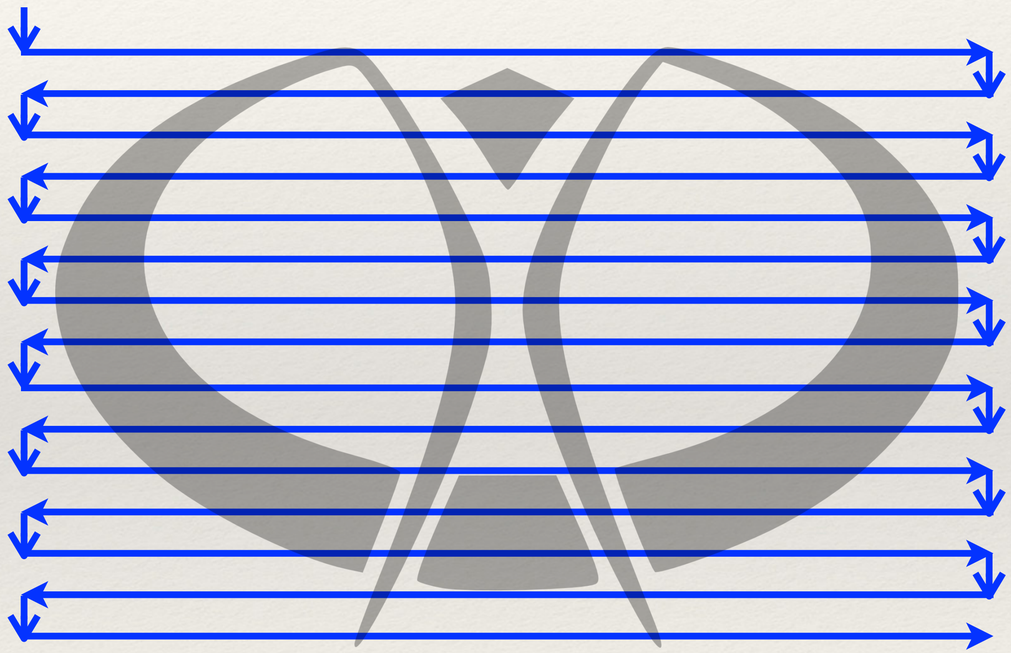
- **Absolute Coordinates** – Your design covers the entire laser bed. Coordinates are unchanged.
- **Current Position** – A chosen corner or midpoint of your design is placed on the laser bed exactly where the laser head is at the start of the job.
- **User Origin** – A chosen corner or midpoint of your design is placed on the laser bed at a point you have designated as "*origin*" using the keypad. Useful with jigs.

3½ Types of Layers

- **Line** – aka *vector*. The laser follows the line you drew, firing continuously*. May be used for cutting (all the way through) or engraving line art. A line has no defined width.
- **Fill** – aka *raster*. The laser goes back and forth to fill the **area** inside the lines you drew, firing when inside the area. Commonly used for engraving, but can also go all the way through.
  - **Offset Fill** – Like fill, but the laser follows the shape of your design instead of just going back and forth.
- **Image** – aka *bitmap*. A type of *raster*. The laser goes back and forth, firing in a dot pattern to mimic continuous tones in a non-vector image you imported. (Lasers are not great at this.)

Raster Operation

- Laser travels back and forth and back and forth
- Laser turns rapidly on and off to create the desired pattern of marked and unmarked pixels
- Usually used for **engraving**
- Thin materials can also be **cut** this way



Power

More is more.

0* to 100%

*Any power below about 10% is 0%. Because physics.

Speed

More is less.

measured in mm/sec

The head has to speed up and slow down as it maneuvers through your design. It’s possible to set the speed too high and get distorted shapes.

Range of Effects on Wood

- no effect
- slight color change (a little darker, like toast)
- strong color change (as dark as it gets, starting to burn)
- shallow depth engraving
- deeper engraving
- cut all the way through
- extra discoloration and charring on cut edges
- major charring on cut edges or FIRE

Range of Effects on Acrylic

- no effect
- slight change in surface texture
- shallow depth engraving
- deeper engraving
- cut all the way through
- extra melting on cut edges

Range of Effects on Glass

- no effect
- slight etching of surface texture
- slight etching of surface texture
- slight etching of surface texture
- cracks or shatters!

Engraving for Depth

- You have SOME INFLUENCE on engraving depth by adjusting power and speed, in materials that burn like wood or vaporize like acrylic.
- Laser does not directly control depth
- Depends on consistency of the material

Laser Cutting for Assembly

- You can build structures out of laser cut parts.
- Things to be aware of:
  - Laser kerf (lost material on a cut line), about 0.004”
  - Laser cut edge is NOT at a perfect right angle.
  - Laser cut edge might not even be straight!

Safety Third



High Voltage Inside!

- The laser works on 20,000 volts and up to 30mA. LETHAL.
- It's all inside the chassis. Don't open any of the service panels!
- Perfectly safe if you keep out of the interior circuitry.
- Don't spill your drink into the machine!



Beam is INVISIBLE!

- It's a frickin' laser. It will burn you if you let it. It can destroy your eyes in an instant.
- The windows are opaque to the laser wavelength. If you keep the lid closed, it can't get out. Always keep the lid and side doors closed.
- Special authorization is required before attempting any operation with the lid or doors open.

Don’t Stare at the Flare

- There’s often a bright visible light emitted right where the laser beam hits the work.
- This is not the laser beam, it’s just a white light.
- As long as you’re looking through the window, it’s safe to look.
- Like any other very bright light, it can dazzle you and cause eye fatigue. Don’t stare at it.

You're Playing With Fire

- When the laser hits flammable materials, they burn.
- If the settings are wrong, or if you're just unlucky, the fire can flare up and get out of control.
- YOU MUST BE IN THE ROOM AND SUPERVISING THE LASER WHENEVER IT IS RUNNING.
- Hit the Stop button, jog the head out of the way if necessary, and put out the fire. Spray a bit of water if you have to.
- Use the CO_2 fire extinguisher if needed.

How to Supervise the Laser

- You must remain in the room. Pause the job if you have to leave.
- Be aware of the hazard level of your job, and pay more attention when there's a higher risk of fire or other hazard.
- No headphones. You need to use your ears to be aware of changes in how the equipment is working and how the material is reacting.
- Manage your distractions. It's OK to work on the computer to prepare your next job, if you're comfortable that the job is reasonably safe. Reserve a share of your attention for safety.
- You do not need to stare at the laser throughout the job.

Where There's Fire …

- Most materials you'll cut or engrave generate some smoke and/or stink.
- The exhaust blower MUST BE ON whenever the laser is operating.
  It should turn on automatically, but check to be sure.
- If the laser starts to fill up with smoke, STOP the job and check the ventilation system.
- Even ordinary smoke isn't that great to breathe; use common sense about your exposure.
- Wait a few seconds for the smoke to clear before you open the lid after your job finishes.

Vinyl and PVC: NO NO NO NO NO

LASER + VINYL = CHLORINE GAS

A little bit of chlorine gas will destroy the machine and make you sick. A little bit more will kill you.

Don’t laser vinyl or PVC.
Don’t laser any plastic you aren’t sure about.
Fake leather is *probably* vinyl too, unless credibly marked laser-safe.

NO MEANS NO

Other Bad Material Choices

- ABS + laser = cyanide gas. Don't go there.
- Polycarbonate plastic thicker than 1mm (melty mess)
- Polystyrene or polypropylene foam will catch fire.
- Fiberglass can't be cut and makes noxious fumes.
- Leather tanned with nasty chemicals (chrome)
- Anything you aren't sure about.
- Check the web for info on other materials.

Good Materials to Cut

- Most woods work fine. (Avoid treated woods)
- Paper, cardstock, cardboard cut fast (watch for fire)
- Acrylic (lucite, plexiglas) is perfect (a little smelly)
- Leather if vegetable-tanned or chrome-free (VERY smelly!)
- Thin mylar is good for stencils
- Natural fiber cloth (cotton, etc.)

Layered Materials

- Laser can remove top layer(s) to reveal lower layers
- Special laminates designed for laser (colored layers)
- Masking tape (+ spray paint)
- Spray paint (+ etch)

Marking Metal

- We can't cut metal, sorry. That's a different kind of laser.
- Anodized aluminum: bleaches to silvery white
- Painted/coated metals: cuts away the coating
  (and generates fumes that might be toxic)
- Cermark: permanent black mark on most metals

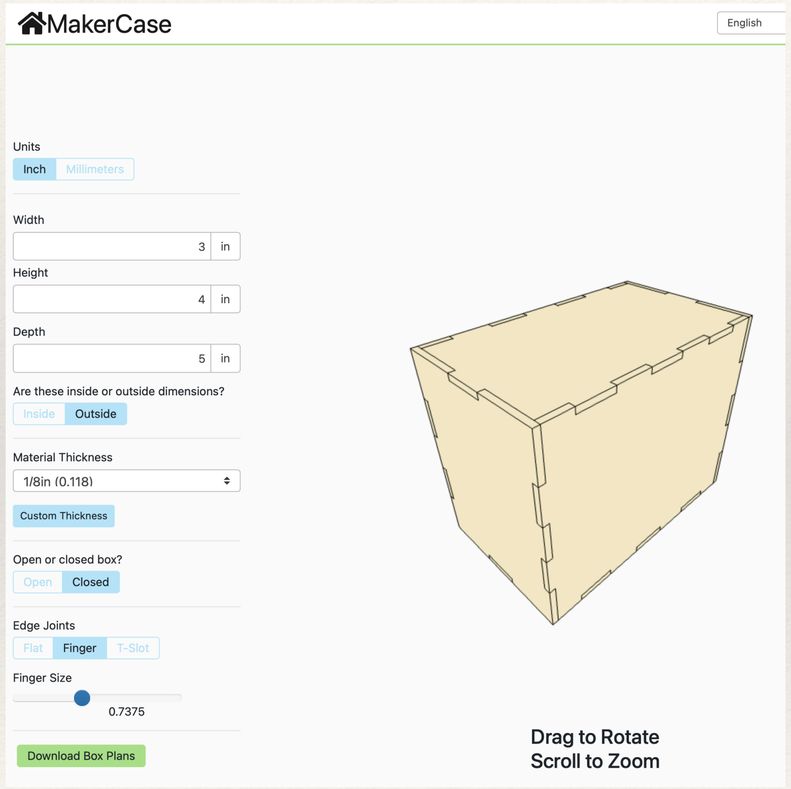
Design Methods

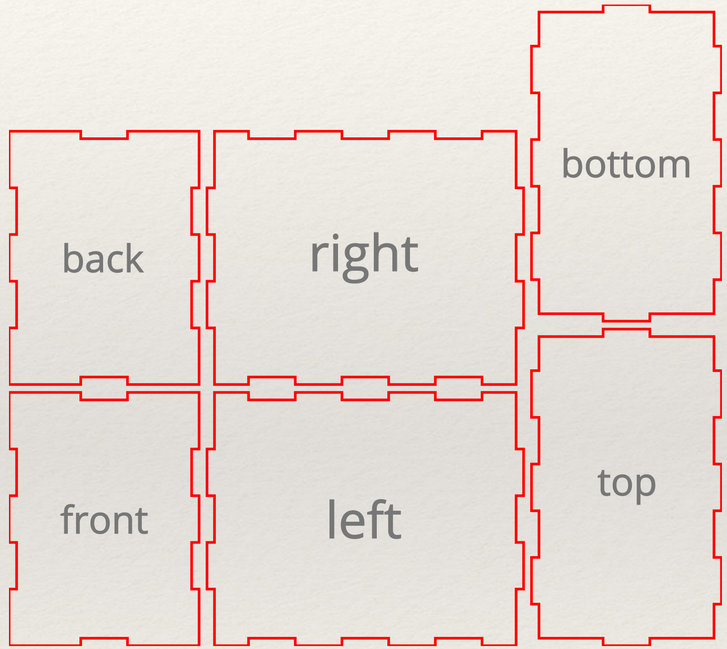
- You’re not limited to what you can draw in LightBurn.

Ways to Use Non-Vector Artwork, Photos

- Redraw the design in LightBurn or another vector drawing program, or …
- Trace the edges automatically
  - LightBurn has this built-in.
  - CorelDraw, Illustrator, Inkscape, etc. can also do this.
- Import as an Image layer and let LightBurn dither it to simulate gray levels
- Transform in an image editing program (like Photoshop) before importing as an Image layer

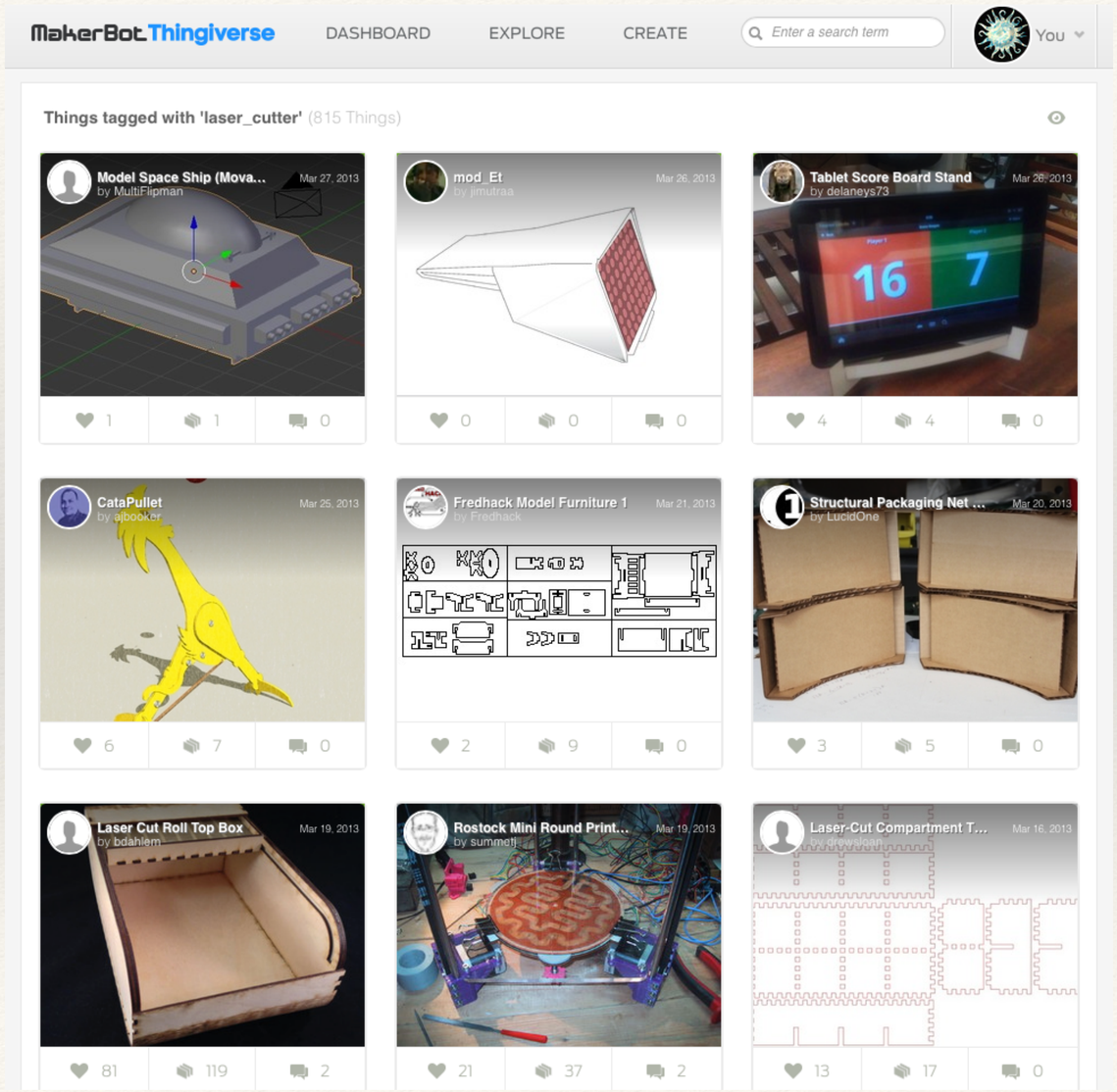
Use a Design Tool





www.makercase.com

Search the Web for Existing Designs

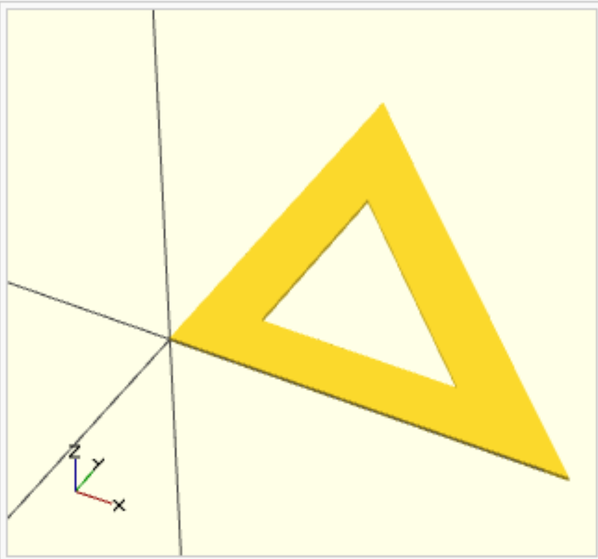


Write a Program

OpenSCAD, Kokopelli

Example

```
polygon(points=[[0,0],[100,0],[0,100],[10,10],[80,10],[10,80]], paths=[[0,1,2],[
```



Polygon example

kokopelli: gear.cad

kokopelli 0.2

```
tooth.shape = True
tooth &= reflect_y(tooth)

# If we have an odd number of teeth, then we can't take
# advantage of bilateral tooth symmetry.
if N % 2:
    tooth &= -X
    teeth = reduce(operator.add, [rotate(tooth, i*360/N)
                                  for i in range(N)])
else:
    teeth = reduce(operator.add, [rotate(tooth, i*360/N)
                                  for i in range(N/2)])

teeth += circle(0, 0, RR)
teeth &= circle(0, 0, RO) - circle(0, 0, RR*0.9)
teeth.bounds = circle(0, 0, RO).bounds
teeth = extrusion(teeth, -0.1, 0.1)

teeth.color = 'red'

# Create a set of six ribs inside the gear
ribs = rectangle(-0.002*N, 0.002*N, -RR*0.95, RR*0.95)
ribs = reduce(operator.add, [rotate(ribs, i*120) for i in r
ribs += circle(0, 0, 0.4)
ribs -= circle(0,0,0.25)
ribs -= rectangle(-0.06, 0.06, 0, 0.3)
ribs = extrusion(ribs, -0.08, 0.08)
ribs.color = 'green'

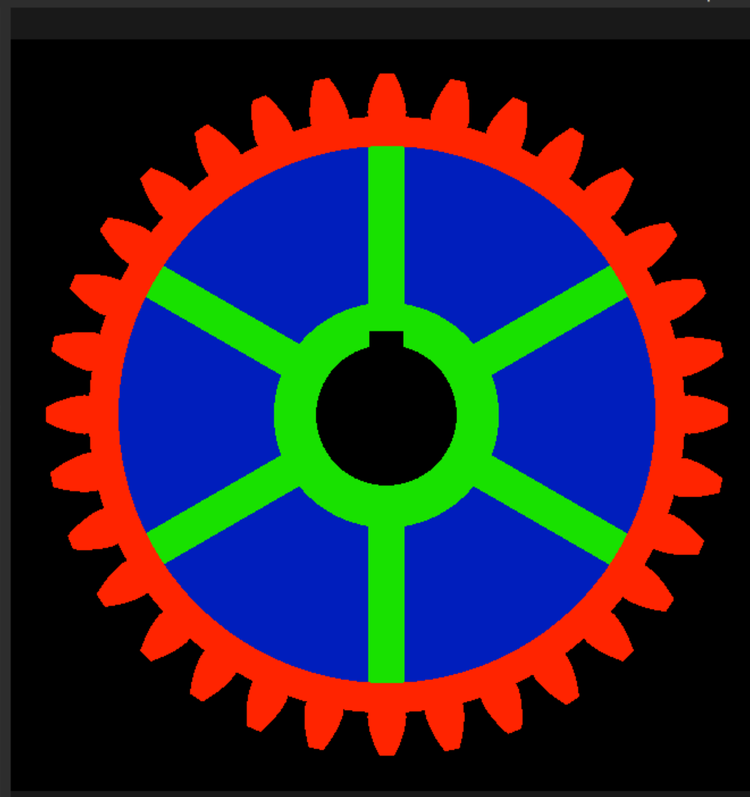
# Create a base for the gear
base = circle(0, 0, RR*0.95) - circle(0, 0, 0.35)
base -= rectangle(-0.06, 0.06, 0, 0.3)
base = extrusion(base, -0.04, 0.04)
base.color = 'blue'

cad.shapes = teeth, ribs, base

"""
Notes:

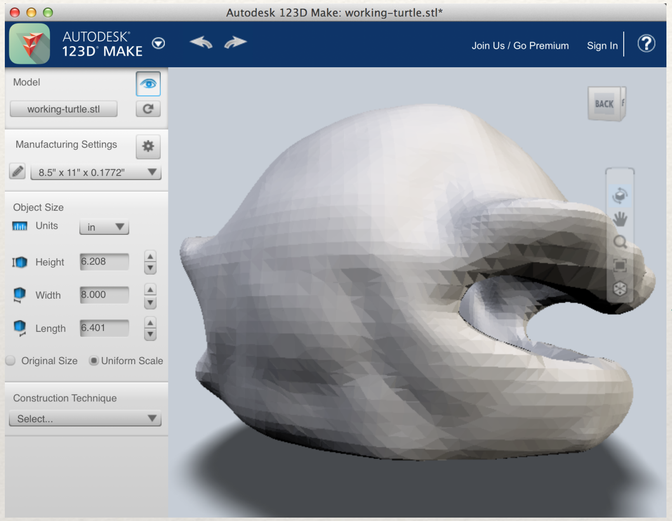
(1)
We want to find the angle such that the involute curve
intersects a circle of radius R, where the involute is being
unwound from a circle of radius RB (and RB < R)

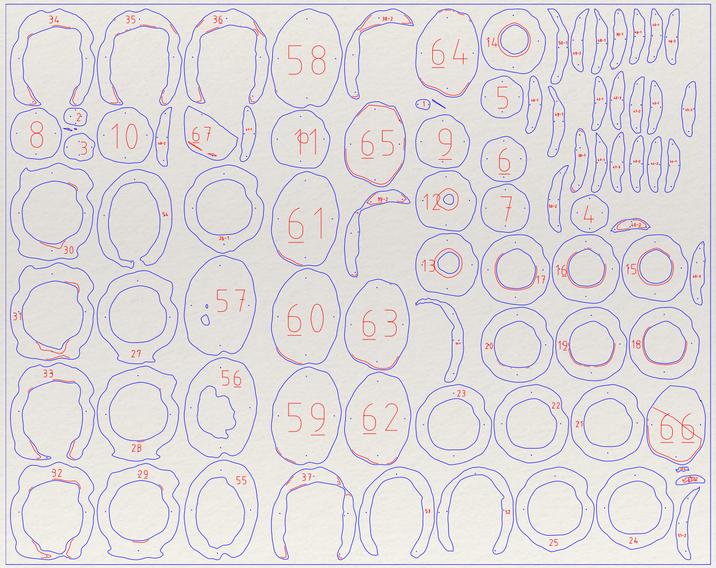
The involute has coordinates
    x, y = RB*(cos(t)+t*sin(t)), RB*(sin(t)-t*cos(t))
```



Re-render the output image

Slice a 3D Model





Unfortunately, this software (123D Make from Autodesk) is no longer available. You can do something similar with 3D CAD software, but the manual process is tiresome. Let me know if you find a new software solution for this job!

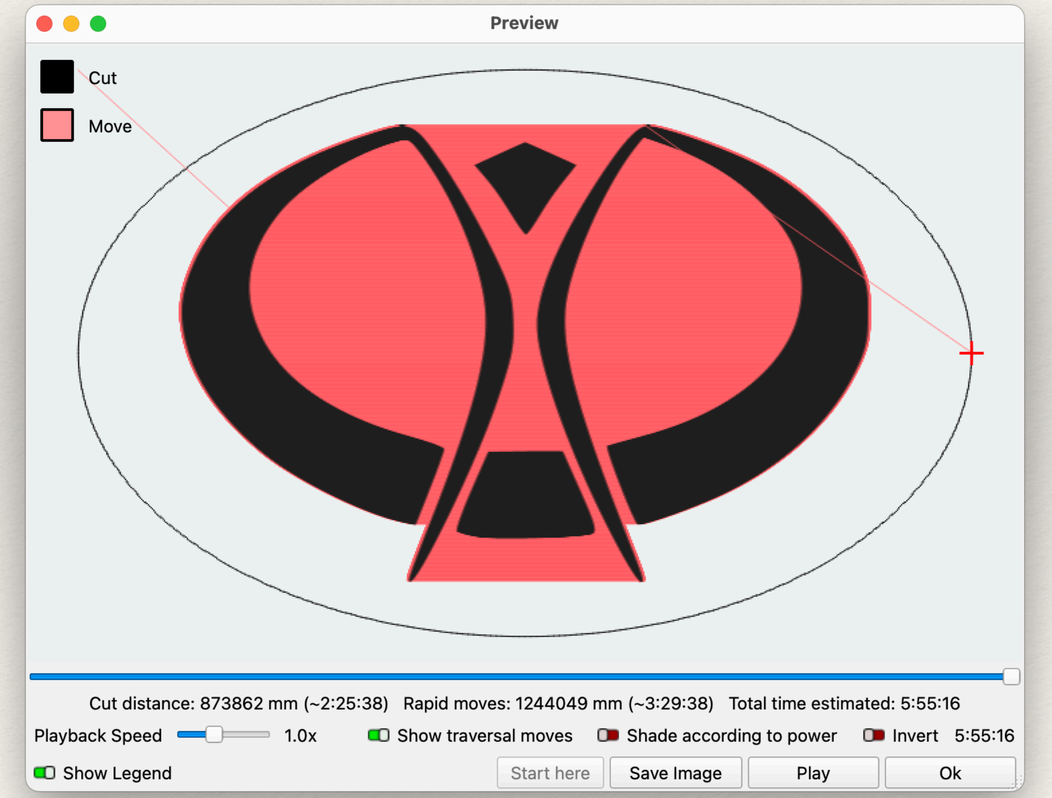
Bring Your File into LightBurn

- File→Open opens the file in your current window, replacing what's there already
- File→New Window first if you still want to see what's open already
- File→Import adds the file contents to your current window
- LightBurn matches up your colors to its own and sorts objects into its layers.
  - For some programs, you can download a LightBurn palette to draw with
- Beware of traps like duplicate objects, hard-to-see objects, loss of fill colors, etc.
- Use LightBurn's drawing tools to make any needed adjustments
- It can be handy to have the original drawing program available for some changes

Use Preview to Check the Job



- It’s always a good idea to look at Preview before running the job.

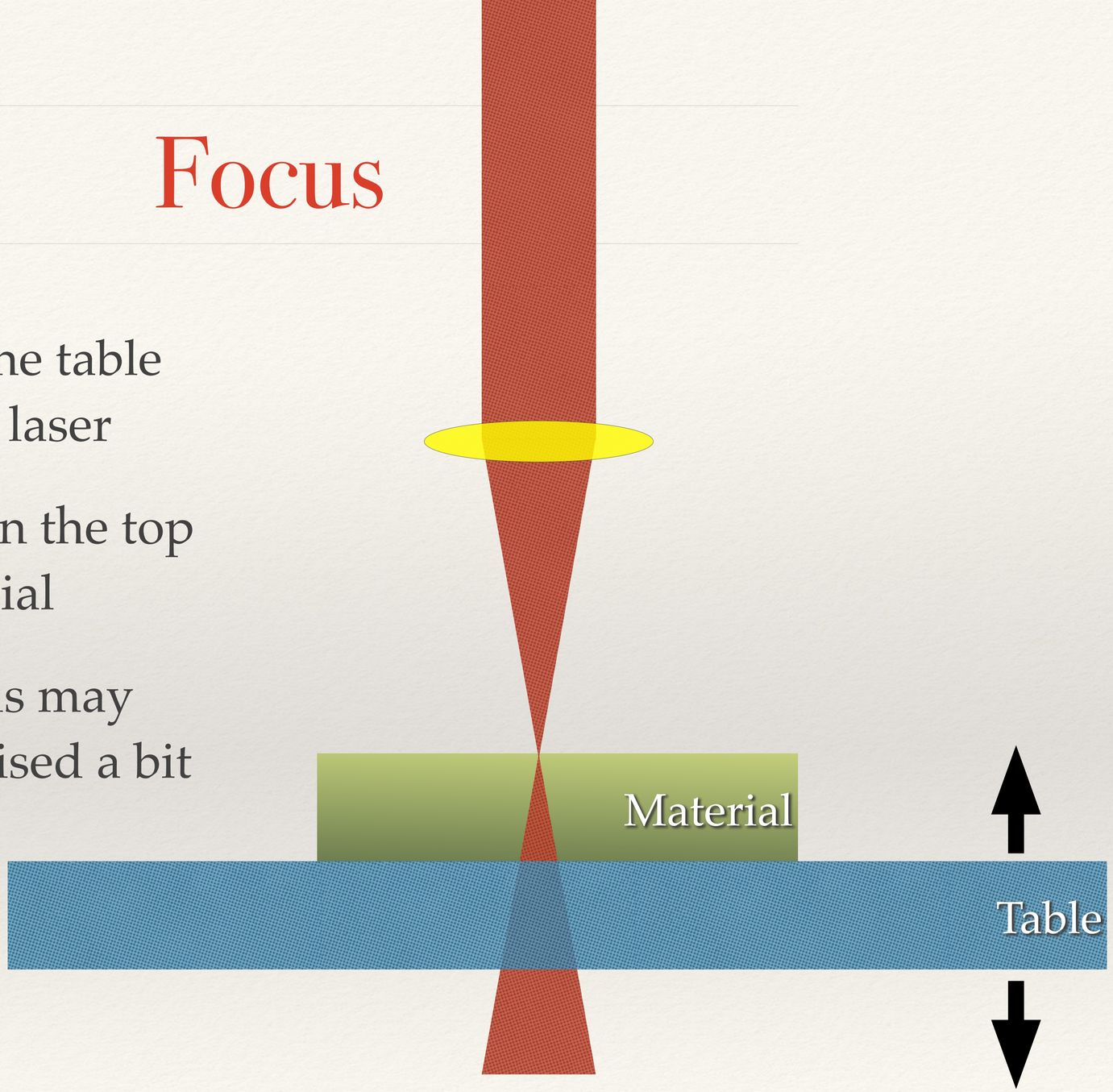


Starting Up

- Chiller on first!
- Laser: turn key switch and turn red knob
- Check that exhaust fan is running
  (listen or feel for the breeze)

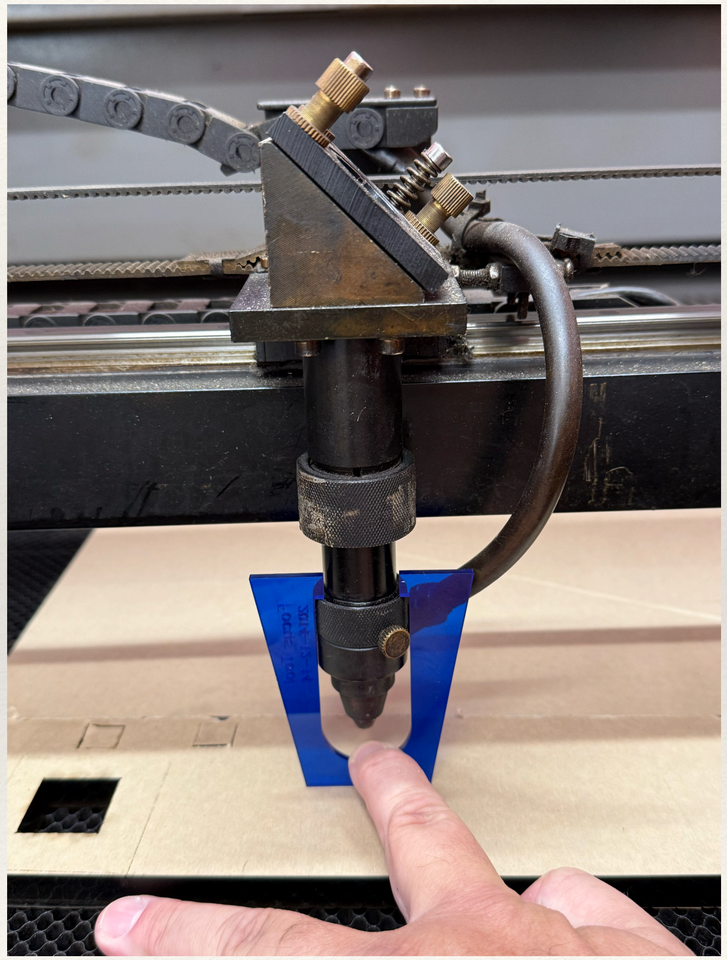
Focus

- Raise or lower the table (Z axis) to focus laser
- Usually: focus on the top surface of material
  - Thick materials may cut better if raised a bit



Manual Focus

- Lower table
- Move head over the material (centered is best)
- Hang focus tool on laser head
- Raise table until the material touches the tool
- Remove tool

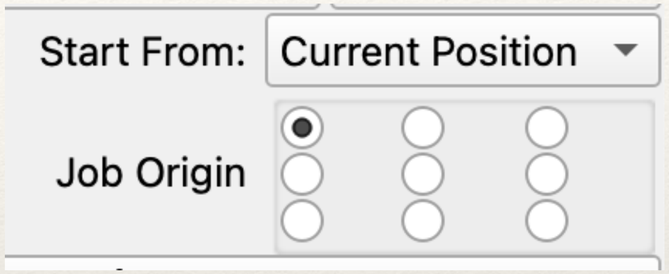


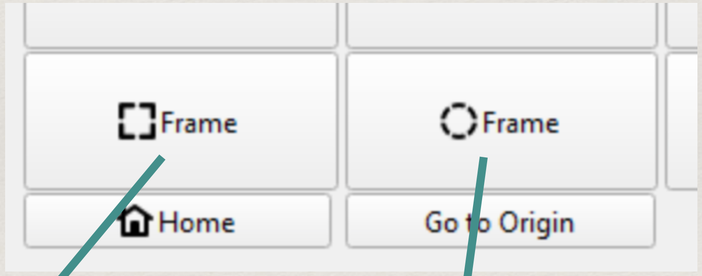
How to Move (“Jog”) the Laser Head

- Usually best: use ⬆️⬇️⬅️➡️ buttons on the keypad
  - Easy to watch the laser head while moving it
  - Use Speed button on keypad to adjust rate of motion
- Alternative: use the Move panel in LightBurn
  - Harder to watch the laser head
  - Can move to numeric positions or by numeric offsets
- DO NOT ATTEMPT TO MOVE THE LASER HEAD BY HAND unless the laser is powered off, and then only slowly and gently.

How to Position the Job? (1)

- Case 1: if you have no special requirements:
  - Select *Start From: Current Position* and pick a *Job Origin* in your design using the 3x3 buttons.
  - Put the material on a convenient part of the grid.
  - Move the laser head to the point on the material matching the point you chose as *Job Origin*.
  - Use *Frame* buttons to test that the job will run in the expected position





How to Position the Job? (2)

- Case 2: if you need a specific alignment with the material
  - Select *Start From: Absolute Coords*
  - Put the material on a convenient part of the grid
  - [Under Camera Control, select Update Overlay]
  - Select the entire job and drag it to the desired position on screen.
  - Always use the Frame buttons to test that the job will run in the expected position
  - [Note: Camera is not 100% accurate.]

How to Position the Job? (3)

- Case 3: mass production of the same design
  - Create some sort of jig that will hold the material in place
  - Place a spare piece of your material in the jig
  - Use any technique to line up the job with the jig
  - Test and adjust until alignment is perfect
  - Now you can make as many as you want, just put the material in the jig and go, repeat until done

Basic Settings: Lines

- Speed: how fast you want the laser head to move, in mm/sec
  -
- Power: how much energy the laser emits when firing, in percent
  -
  -
- Passes: how many times to do the operation, usually 1

Basic Settings: Lines

- Speed: how fast you want the laser head to move, in mm/sec
  - Actual mechanism may be slower near corners or in curves
- Power: how much energy the laser emits when firing, in percent
  - Power Max: power when the laser motion is up to speed
  - Power Min: lowest power when the laser motion is slow (controller varies power between Max and Min)
- Passes: how many times to do the operation, usually 1

Dealing with Power Min

- Power Min can be equal to Power Max. At least you'll know that the laser won't surprise you by reducing its output power.
  - … but that may be too much power in the corners or curves, where the head has to slow down to change direction.
- Power Min can't be less than about 10%, because the laser just won't fire at all at such low powers.
  - … but that might be too little power in the corners or curves.
- As usual, the best setting will depend on your design, your material, and your intention. You may need to run multiple tests to find the best value.

Finding the Best Basic Settings

- Start with a rough estimate based on experience, such as:
  - Your own experience with similar materials
  - Settings from the Material Library in LightBurn
  - Settings from user entries in the log book
- Then either:
  - Do a test cut, look at the results, guess an adjustment, repeat until satisfied with the results. Or,
  - Use LightBurn's *Laser Tools→Material Test* to create a grid of tests, varying speed and power systematically. Use the best result.

When the Laser is Too Powerful

- When you are already using the maximum practical speed and the lowest power the laser can fire at, and it's still too much, what can you do?
- Ideally, you'd use a different laser: a CO_2 laser with lower max power, or a diode laser. Our 180W laser is not the best at fine work.
- LightBurn's **perforation mode** can help. Start with cut and skip set to 0.1mm each (half power), and vary the ratio to change the effective power. For example, cut 0.05mm and skip 0.15mm to get one-quarter power.

Solving Problems with Multiple Passes

- Usually you will use just 1 pass, because it's the fastest.
- If you're trying to cut thick wood at 100% power, you may find that if you lower the speed enough to cut all the way through, the material around the cut begins to char or even catches fire. Try a faster speed and compensate with additional passes.
- If you're trying to cut thick acrylic, you may find that the material heats up and melts enough to re-seal the cut. Again, try a faster speed and multiple passes. The material cools down locally between passes.
- You can vary the focus height from pass to pass.

Your Results May Vary

- Settings that were perfect last time may not be perfect this time!
- Natural materials (e.g., wood) *will* vary. Manufactured materials can, too.
- The performance of the laser can vary, too. If it's a bit out of alignment or the mirrors are dirty or slightly damaged, it'll be worse. If you notice a big change in performance, notify Paul and write it up in the log book.
- If you need the absolute best results, test and adjust your settings. You'll need to **have some extra material** on hand.
- You may be able to choose settings that are more reliable without accepting much compromise in quality. A cut that doesn't go all the way through everywhere it's supposed to can ruin your whole job. **Allow margin**.

Log Book

- Check the log book for settings, problems
- Write down your experiences in the log book
- Make note of any settings that worked or didn’t work
- Sketches, thoughts, poetry

colaser.org

- https://colaser.org is the web site for the laser
- reference materials, including manuals
- the latest news and tips
- scheduling info
- your articles (please!)

Scheduling Time on the Laser (details still TBD)

- Check the read-only calendar to find an open time, (probably at sdcolab.org/calendar)
- short form to fill out online (TBD)
- a volunteer will try to accommodate your request with a scheduled time, ***including*** opening the building for you
- try to give as much notice as you can

Credits

- Safety Third badge courtesy of Aaron Muszalski, #KCrew12 (modified)