Laser Cutting & 3D Printing Manual

Comparison Chart

Category	Laser Cutter	3D Printing
Material	Acrylic/Plywood/ Cardboard/Paper	PLA or ninjaflex (plastics)
Strength	Material dependent	Weak in tension, especially among vertical layers
Geometry	Planar (can be assembled into 3d shapes)	Complex Shapes, limited with overhangs
Scale	48” x 24” for the larger one	9” x 6” x 6” tall
Speed	Fast but requires assembly	Fast for small parts but slow for large ones
Material Waste	Large, dependent on part size and orientation	Minimal (rafts and supports)
Dimensional Changes	Width of laser affects cut minimally	Shrinkage affects entire part
Location & Availability	Back of shop Mon-Fri until 6pm usually	Mechatronics lab Always available

Recommendations

Use laser cutter if:

- Part is planar or can be easy assembled from planar components
- Desired part needs to be structural rigid

Use 3D Printing if:

- Complex Geometry
- Desired part is very flexible (use ninjaflex material)
- Part is very small (largest dimension < 2”)

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Laser Cutter: How To

Disclaimer: This tutorial indicates the general guidelines of using the Laser Cutter. If this is your first time, ask a mechatronics or shop assistant to be trained. Never hesitate to ask questions!

1) Design product as a single planar part or an assembly of planar parts
    a. Draw sketch on a plane and extrude the sketch. Recommended that extrusion depth is equal to material thickness. This makes verifying assembly easier
    b. See next section titled “How to design laser cut pieces for assembly” if desired
2) Save part as .DXF file type. It is necessary to choose orientation of part properly
3) Open “Laser Cutting template” file on computers dedicated to machines. File is located on desktop.
4) Drag .DXF file into template. Typically choose “auto-scale” when importing file.
5) Select image and convert line width to “Hairline”
6) Orient part on template
7) File -> Print
8) When selecting laser cutter as printer, hit preferences
    a. Selection options allow changes in power, speed, and PPT. Use material sample located next to computer to determine appropriate settings. **Disclaimer**: These settings might need tweaking to properly cut your material
    b. Make sure Flow is set to air and that the (physical) air valve is open
9) Print button then sends file to printer
10) Zero the Z-axis to the proper focal length for your material (need to be trained on this step specifically)
11) Recommended: Hit start with the laser cutter lid open. The laser will not activate but the laser head will follow the desired path. Ensure that this path is what you had intended
12) Close lid and hit print again

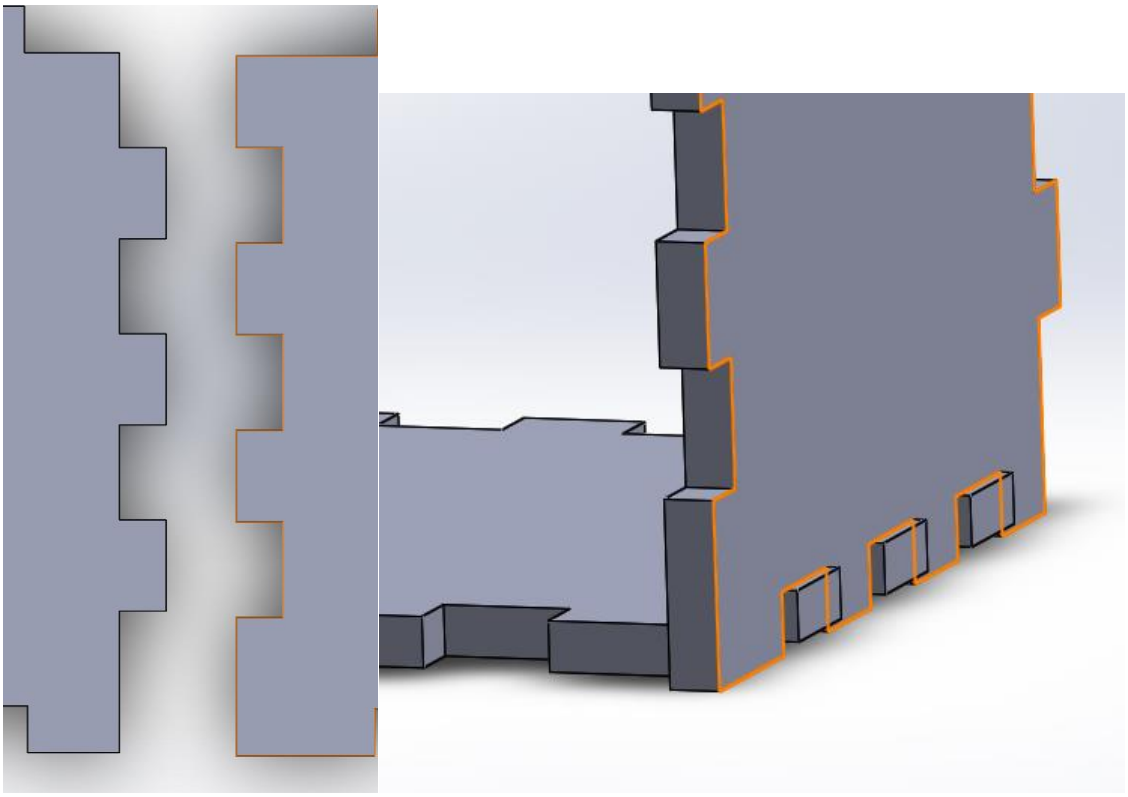
How to Design Laser Cut Pieces for Assembly

Joining Methods:

1. Glue components together – easy but cannot be undone
2. Nuts and Bolts – clamps components together, see section on t-slot Design for Assembly on how to include this in the design

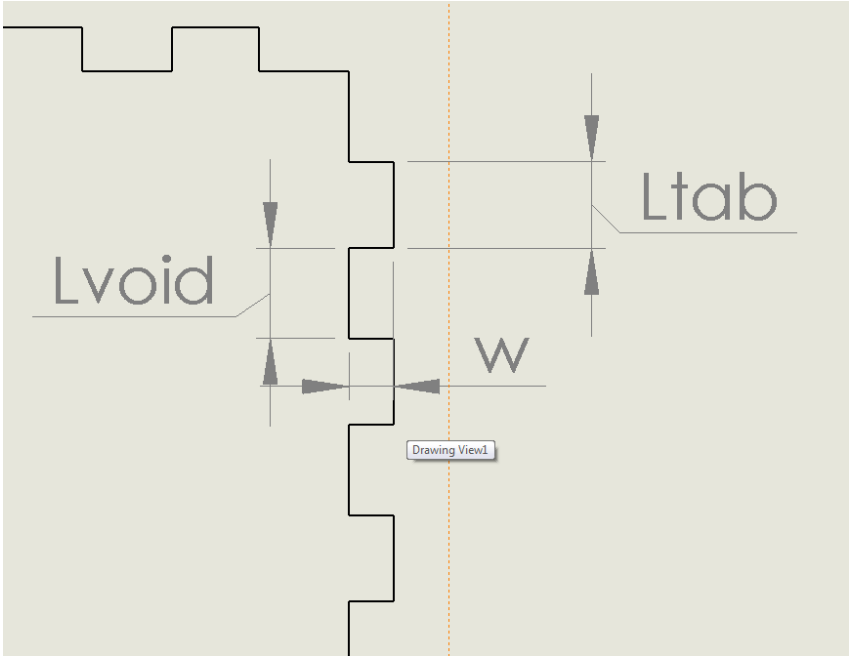
Tab Design

- Used for joining 2 planes at a single edge
- As seen below, the male part (outlined in black) and the female component (outlined in orange) are designed with mirror image profiles, allowing them to assemble as such



- This “mirror image” process allows for easy assembly. The resulting fit is a clearance fit (some allowance to move) due to the laser cutting the actual dimensions slightly less than designed.

- To achieve a press fit (not recommended for beginners), the male and female parts no longer become mirror images. In each case, the tabs need to be made wider and the voids need to be made narrower. The exact amount that these dimensions needs to change is based on the width of the laser and requires some trial and error to get perfect.
    - Difficulties occur when keeping centerline axis of tabs/voids aligned and calculating how much to widen tabs

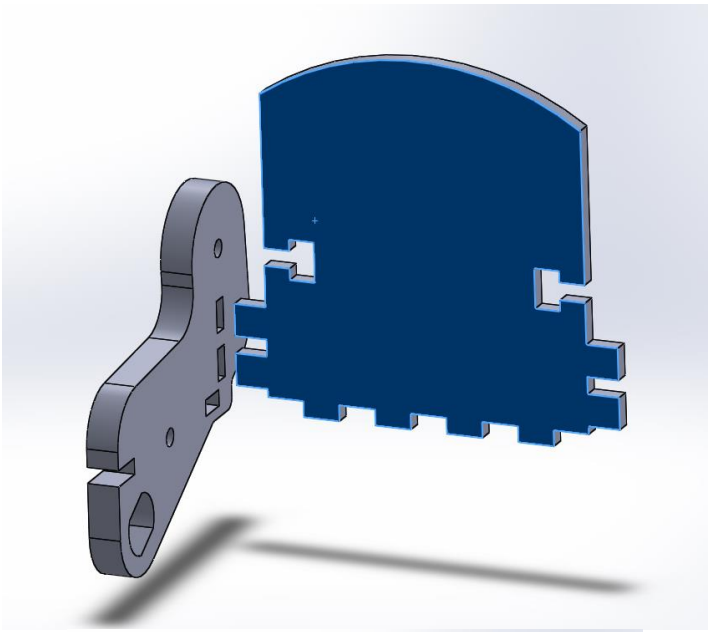


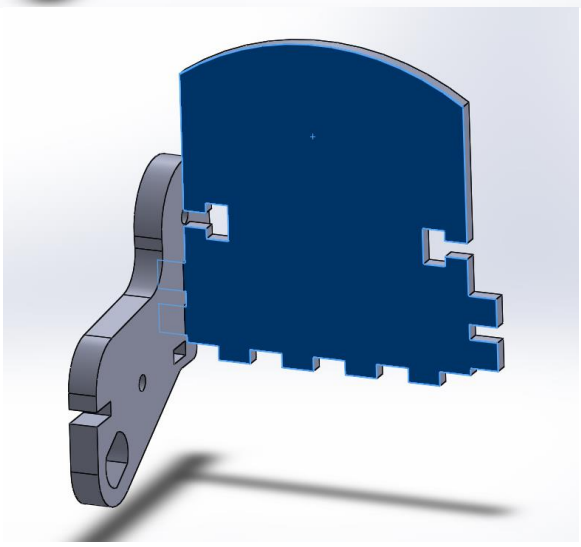
1. Determine the number of tabs/voids desired. 2 things to keep in mind:
    - How long is the edge which is being tabbed?
        i. Recommended tab size is between 0.25” and 3”
        ii. Total number of tabs and voids is recommended to be between 3 and 20 along the edge
    - What is the method of assembly?
        i. Glue works best with smaller tab sizes (maximized surface area)

   ii. Assembly via nuts and bolts recommends a tab size of 1.5”
2. Recommended that *Ltab=Lvoid* for simplicity
3. Recommended that *w* is the thickness of the material. This will create a flush corner
4. Reminder: Male part is shown above, female part is simply mirror image.
5. Assemble in CAD and **check for interference** before going to the laser cutter!!!

Slot Design

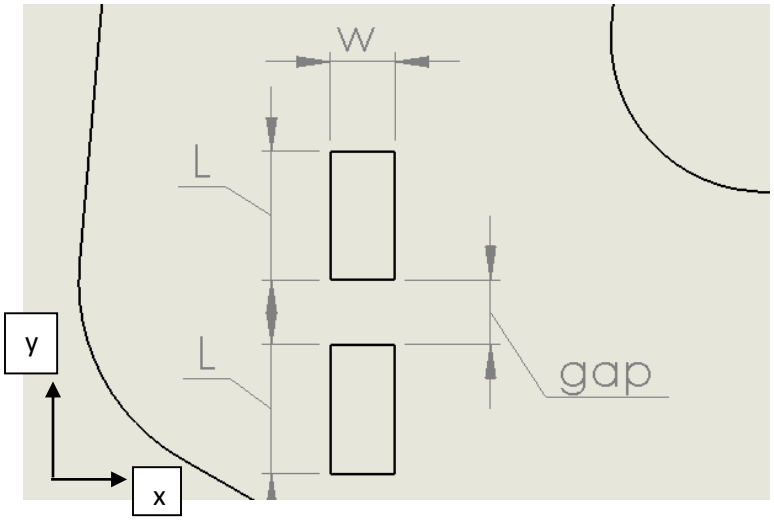
- Used for joining 2 planes, where at least one of which does not end at the intersection
- This design is more complicated than the tab design. Order of assembly matters significantly! There is only one direction that parts can be assembled (compared to the tab design which permits two directions of assembly)
- 2 types of slot design:
    - **Type 1:**
        - As seen in the images below, the blue piece ends at the intersection of the two parts. This blue piece will be referred to as the male part
        - The grey piece does not end at the plane of the blue piece. This part will be referred to as the female part



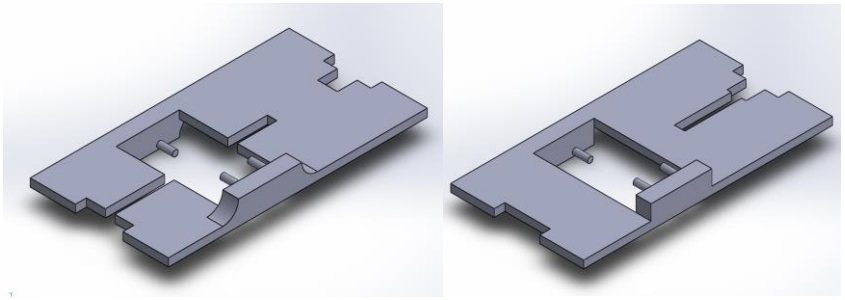


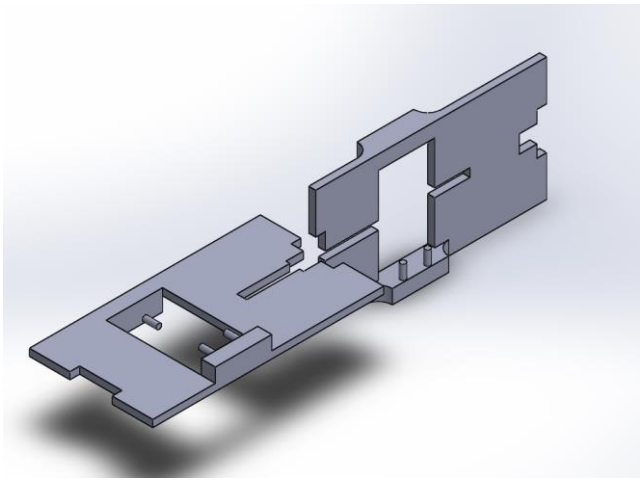
1. The male part is designed the using the tab design described above.
2. The female part needs to mirror the male part but the voids are designed slightly differently.
    a. For the female part below, the mating part exists in the yz plane
    b. *w* should be set to the thickness of the stock material for the mating part
    c. *L* should be set to *Ltab* as designed in the male part

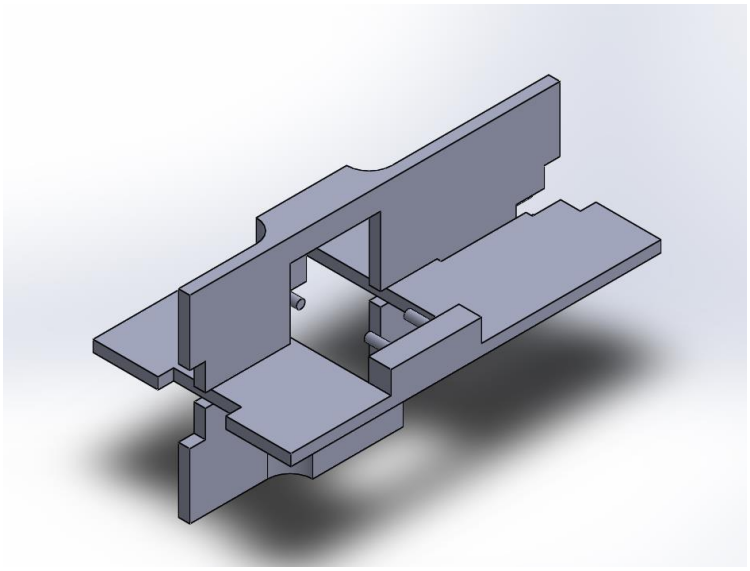
d. *gap* should be set to *Lvoid* as designed in the male part



- **Type 2:**
  - Neither of the parts terminate at the intersection of the assembly

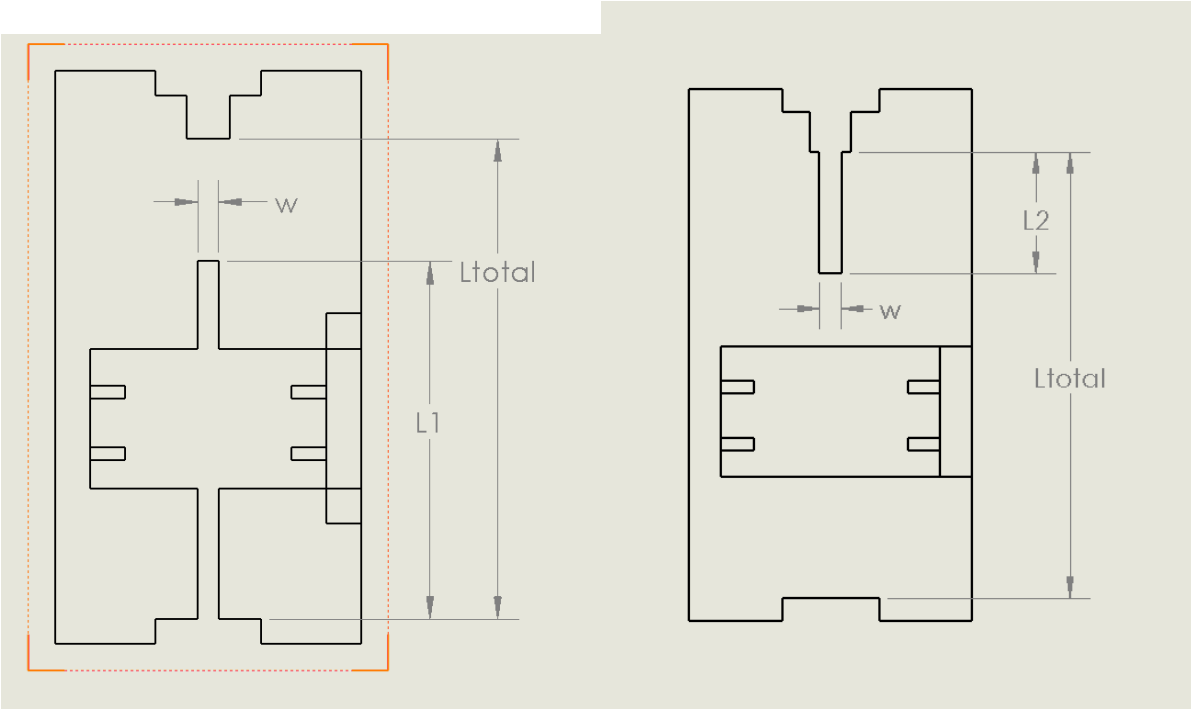






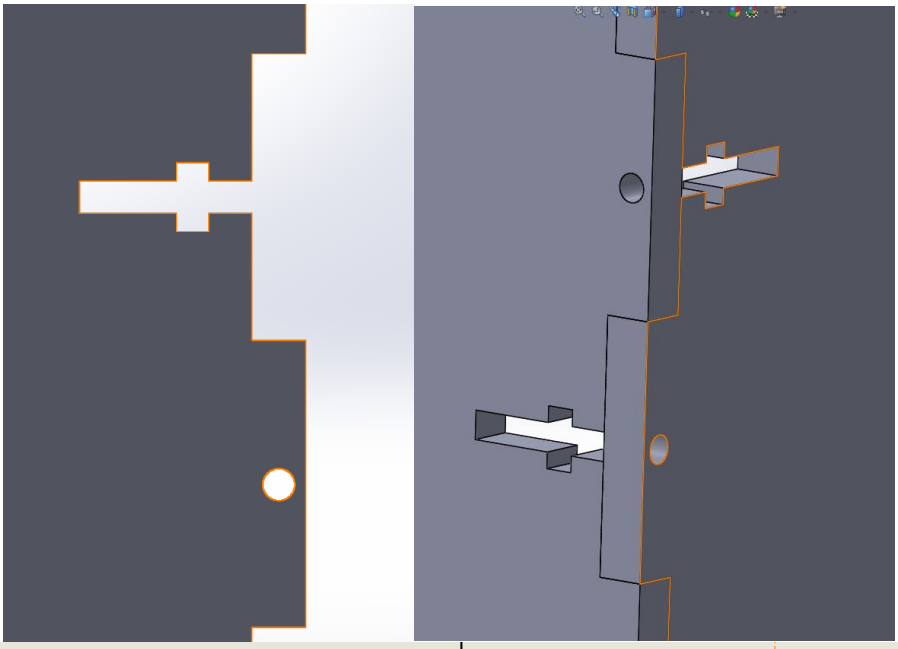
- Note how the assembly of this part can only occur by sliding one part on top of the other

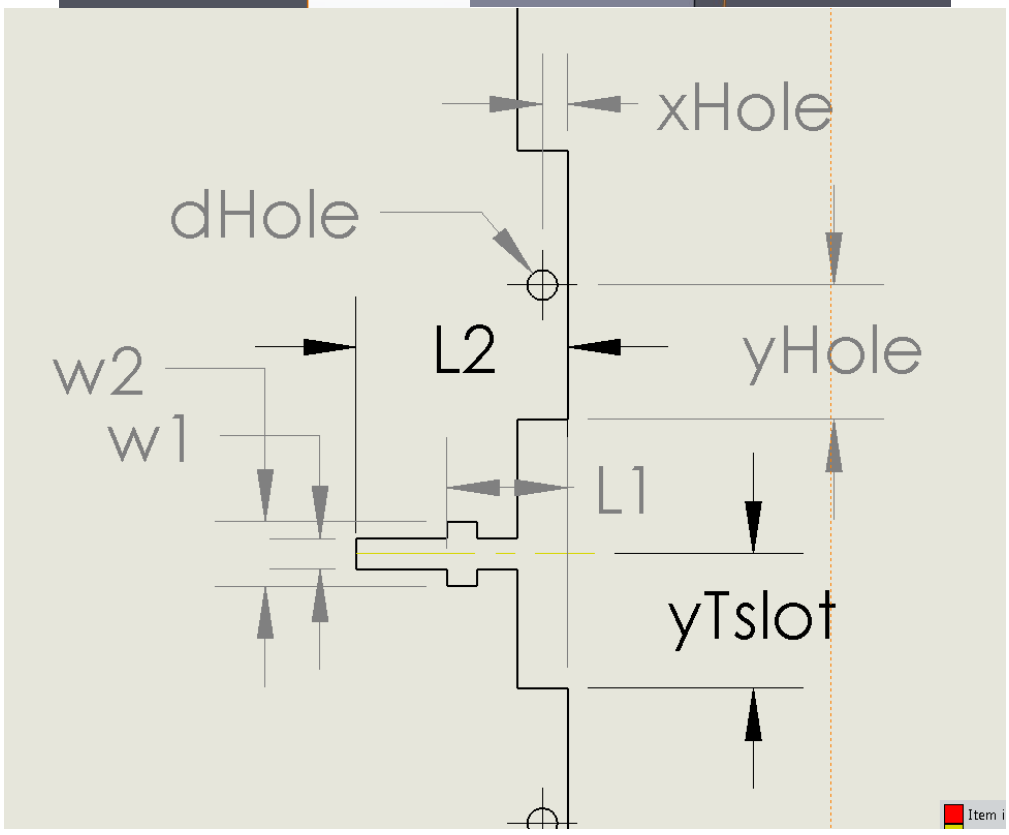
1. Design general shape of parts and define Ltotal, the total length of the overlap during assembly
2. Create a slot in the parts of width w. This width should be set as the thickness of the mating part (or slightly smaller if you desire an interference fit). If using the same stock material for both parts, then w is the same for both.
3. $Ltotal = L1 + L2$. For simplicity, set $L1 = L2 = \frac{Ltotal}{2}$ but this is a design choice. In the parts shown below, setting L1=L2 is not an option due to part geometry.



t-slot Design for Assembly

- Preferred option compared to gluing parts together
- t-slot design can be used on tab design or slot design type 1
- As shown below, the t-slot can be added to both pieces in the tab design described above.
- This guide uses 6-32 1” bolt and nut for examples



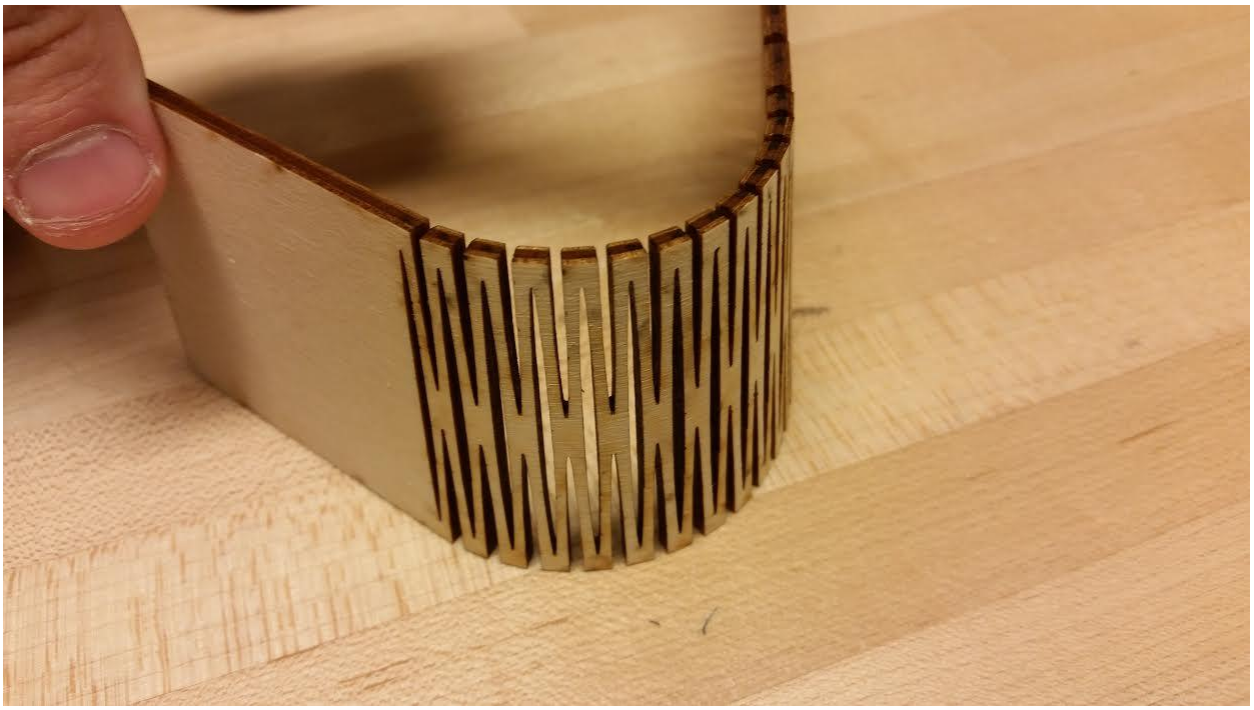


1. Design tab or slot (type 1) design as described above
    - For tab design, these directions can be followed directly
    - For slot design type 1, the t-slot belongs in the male part and the thru hole belongs in the female part

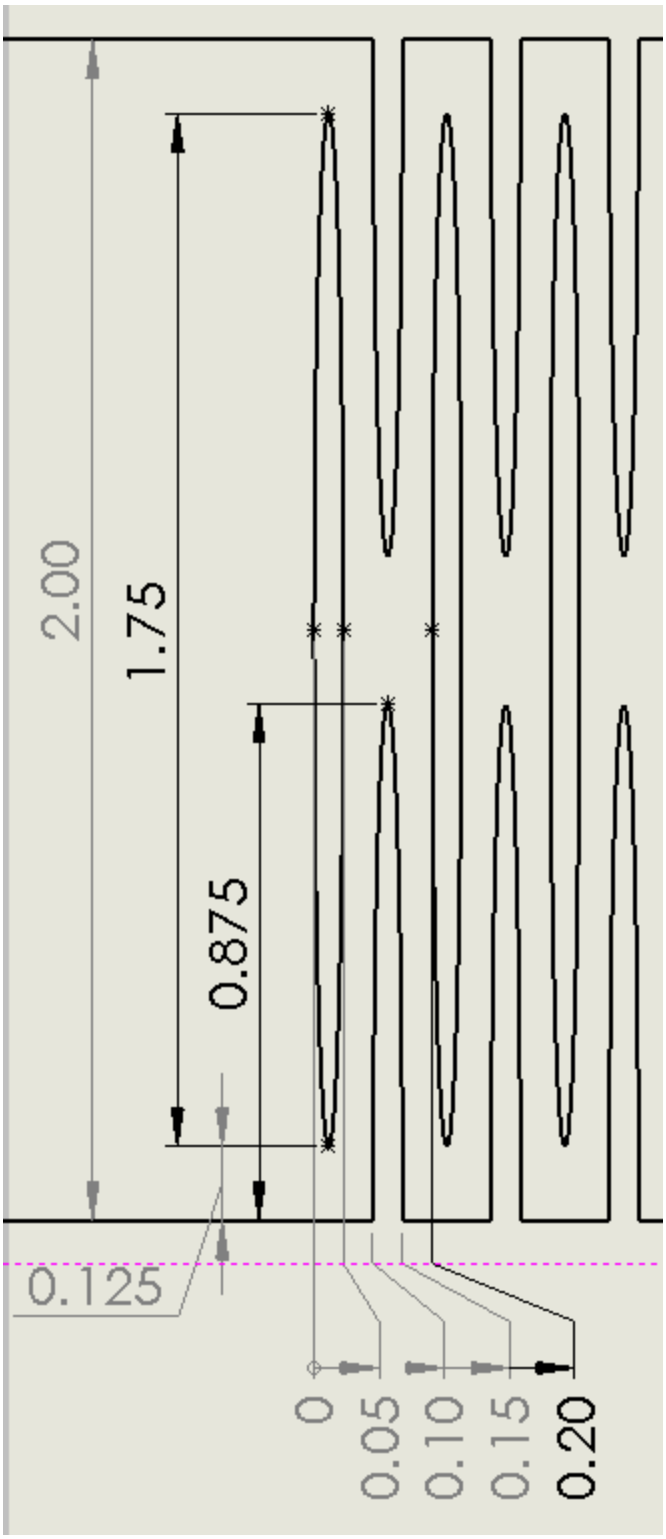
2. t-slot dimensions
    - symmetrical about centerline axis defined by yTslot
    - yTslot – recommended to be centered in void $yTslot = {Lvoid}/{2}$
    - w1 – slightly larger than the diameter of the bolt. For example, bolt diameter 0.132” would result in w1 of 0.15”
    - w2 – slightly larger than width of nut being used but also smaller than the longest diagonal of the nut. For example, nut with width of 0.308” and longest diameter of 0.350” would result in w2 of 0.325”
    - L1 – Recommended 75-90% of bolt length. Do not make this dimension any longer than bolt length.
    - L2 - At least as long as the bolt length

Flexible wood

Description:
Laser cut pattern into 1/8” plywood allowing the material to bend along a radius as shown below.

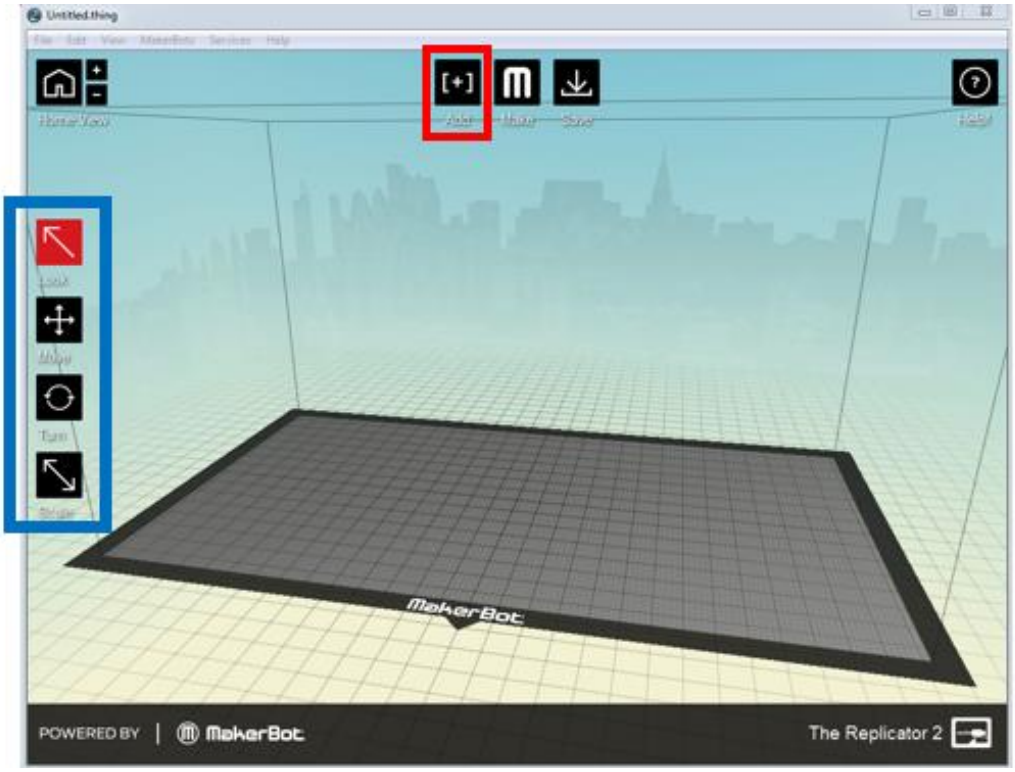


This example is for a 2” wide strip of wood. For larger pieces, it is recommended duplicating the following pattern vertically rather than stretching out the ovals. The dimensioned cad drawing is shown below. The pattern consists of alternating oval cutouts such that the wood is only an eighth of its total width along the major axis of the oval. Square cutouts are easier to CAD the pattern, but stress concentrations at the corners might cause failure of the wood. Varying spacing between the oval cutouts also allows for different bending radii.

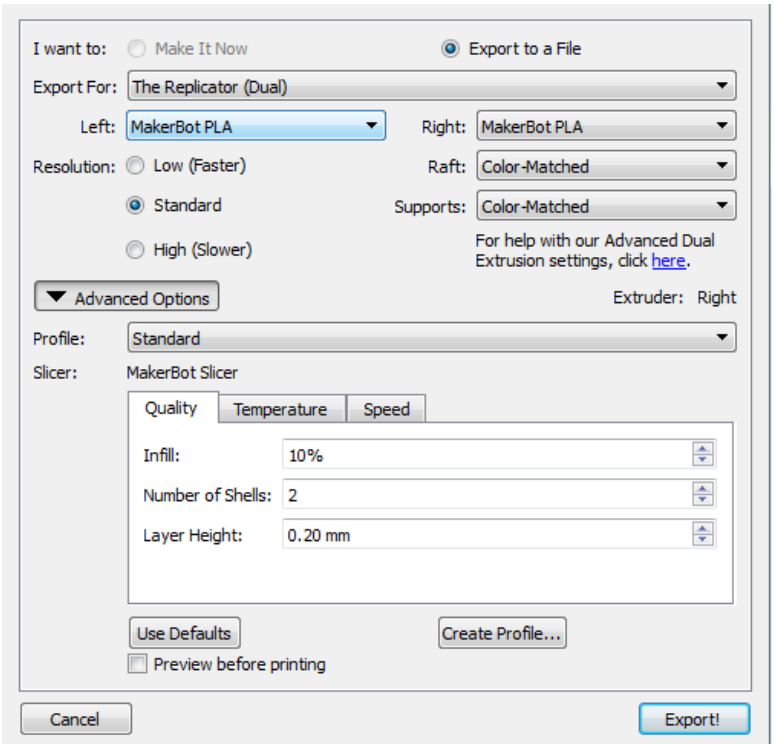

2.00
1.75
0.875
0.125
0
0.05
0.10
0.15
0.20

3D Printing: How To

1) Design part as desired in CAD
2) Save part file type as .STL
3) Open up Makerware
    a. Click “add” button (red) to add .STL file to window



    b. Use tools (blue) to orient and move part. Make sure to lay component on platform (button within move controls)
    c. Print settings:
        i. Hit “Make” (next to “add” button)
        ii. Set extruders to PLA (currently only left extruders work on both printers)

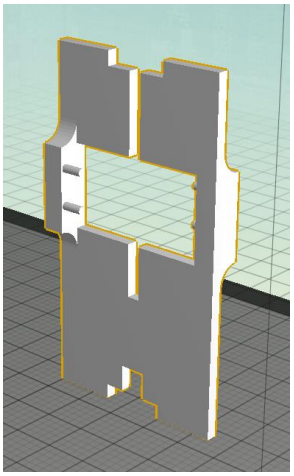


iii. Enable or disable rafts and supports (see section below)
iv. Optional: Set resolution, infill, number of shells, and layer height. Default values are sufficient
v. Check box “Preview before printing” to get an estimate of time required
vi. Export!

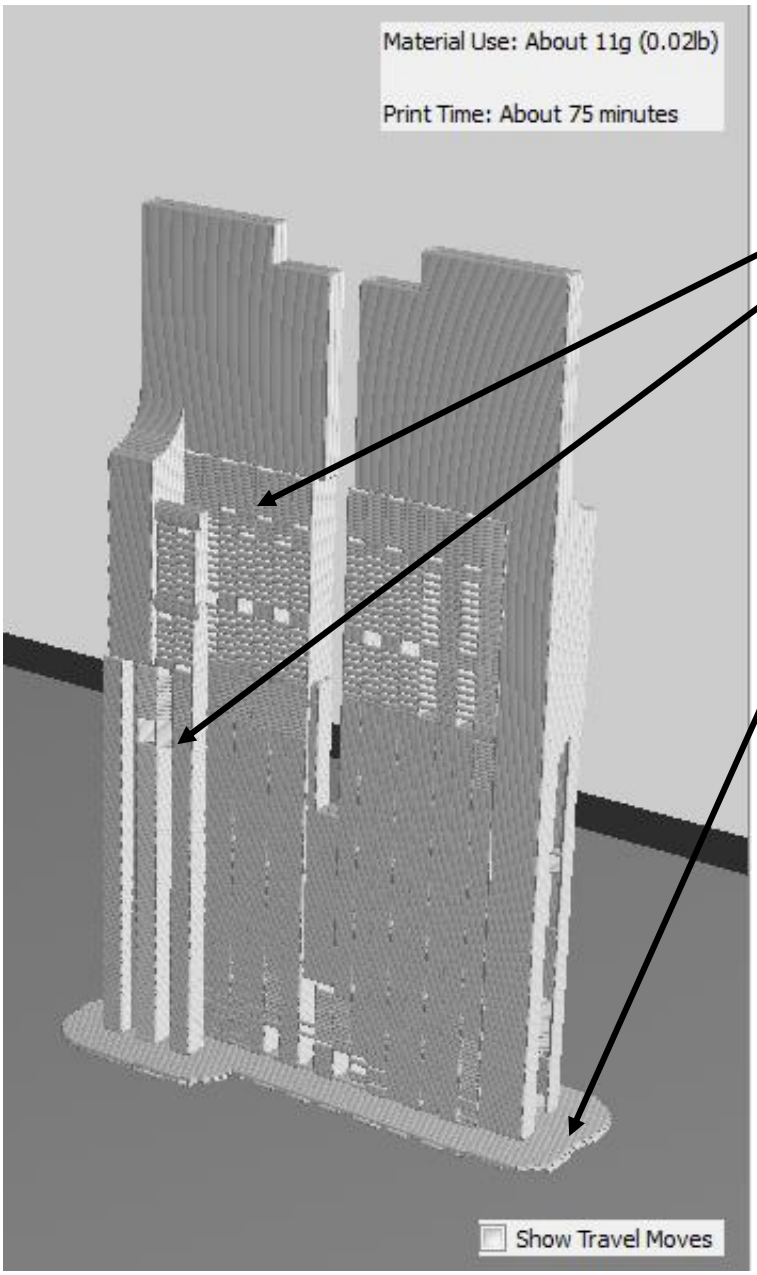
4) Measure final part dimensions and scale accordingly in CAD model to get desired final dimensions when accounting for shrinkage

Example:

Original Part



Preview of Part Printing



Supports: Weak infill used to support overhangs in the original part. Intended to be broken off after part is completed. Recommended if part has overhangs with critical feature dimensions

Rafts: Thick bottom layer which helps plastic adhere to platform. Depending on part, can be very difficult to break off. Recommended in all cases