

SKETCHUP AND 3D PRINTING

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My Experience

- You can see some of the parts that I have designed to date at:
<https://www.shapeways.com/shops/yosemite-models>

Introduction

This handout covers the use of the free SketchUp computer program for drawing a part, the free computer program Netfabb to get the 3D drawing file ready to be uploaded to be “printed” (the process of producing the part using rapid prototyping technology), and Shapeways, a firm which will actually print the part and mail it to you.

Getting Started

- A good reference book for using SketchUp is *Google SketchUp - The Missing Manual* by Chris Grover. It is available from Amazon and other book stores.
- There was once a free SketchUp version which will do everything you need. However, that free version is no longer available online. Instead, they offer a free version which might require more computer resources than you have available based on comments on the Web. It is cloud-dependent which means that it can only be used with an internet connection. I don't like cloud-based computing. But that might be the only option. Go to:

<https://www.sketchup.com/plans-and-pricing/sketchup-free>

- But if you are using a Microsoft computer, email me at jack@yosemitevalleyrr.com and I might be able to give you access to the 2014 full version of SketchUp.
- There are literally thousands of YouTube videos illustrating how to use various tools and solve common drafting challenges. If you get stuck, search Google for “SketchUp Push-Pull tool” or a similar search.
- SketchUp files have a .skp extension. However Shapeways needs a .stl file. To avoid confusion, I set up a main SketchUp folder with subfolders for each part that I draw based on the name of the part (*Fairmont T27 Engine*, etc.) Under each “part” subfolder, I create another subfolder entitled *Sketchup Files*. SketchUp files are in this *Sketchup Files* subfolder. The final file which will be uploaded to be printed (which will be a .stl file) will be in the main folder. I do this because the .skp and .stl file extensions are easily confused.
- For more complex projects, I do a **Save As** often with file names such as *Tank A.skp* and *Tank B.skp*, etc. Even though SketchUp has a multiple **Undo** command, that Undo command won't work after saving a part. Using the **Save As** feature allows me to go back to a previous version of the file if I need to go further back and start over.
- Unless my part is too large, I always print using Smoothest Fine Detail Plastic
- The following table provides the most important design elements for printing a part using Smoothest Fine Detail Plastic for both HO and O scales. For example, a wall supported by walls on two or more sides must be at least 0.3mm thick, which is equal to slightly more than 1” thick (1.03”) in HO or about 5/8” thick (0.566”) in O scale:

Design Standard	Millimeter (mm)	HO Prototype Inches	O Prototype Inches
Min Wall Supported (1)	0.3 mm	1.03 inches	.566 inches
Min Wall Free (2)	0.6 mm	2.05 inches	1.13 inches
Min Wire Supported (3)	0.6 mm	2.05 inches	1.13 inches
Min Wire Free (4)	0.8 mm	2.74 inches	1.51 inches
Min Wire Free (5)	1.0 mm	3.42 inches	1.89 inches
Min Embossed Detail (6)	0.1 mm	0.34 inches	0.19 inches

(1) This is the minimum wall thickness where the wall is supported on two or more sides

(2) This is the minimum thickness for an unsupported wall

(3) This is the minimum thickness of a “wire” which doesn’t bear any weight but is supported on both ends.

(4) This is the minimum thickness of a “wire” which extends out from a part without support.

(5) This is the minimum thickness of a sprue connecting parts

(6) This is the minimum width of a groove “engraved “ into the surface of the part or an item “embossed” on the surface of the part.

By habit I always make a supported wall at least 1-1/8” thick.

- Note that there are limits as to what can be printed in Smooth Detail Plastic and Smoothest Detail Plastic. These are the maximum size of the part
 - Smooth - 282 × 181 × 150 mm
 - Smoothest 282 × 181 × 100 mm
- There are also minimum limits: the length + width + height (in mm) must at least 12 mm.
- Full design guidelines for fine detail plastic are at

<https://www.shapeways.com/materials/fine-detail-plastic>

The most important design guideline is the minimum size that can be printed. For HO it is 1-1/8” (full size) for a wall supported and 2.051” that for an unsupported wall.

For simple parts, just add together the height, width, and length of the part. Or, after processing a part through the Netfabb program (as discussed later) after scaling it for your scale, Netfabb will list the height, width, and length of the part in millimeters. You can add these numbers together—they need to equal or be larger than 12 millimeters (or 26” if you will be printing in HO scale). You can also use the above information during design. For example, say that you are designing a square part for which the prototype dimensions are 8” high by 6” wide by 6” long. That would total 20” total. That size part would meet the standards if you are modeling in O scale, but would be too small in HO. However, there are tricks to still accommodate this standard if you are modeling in HO. You could add a simple “sprue” to one side of the part and make it long enough to meet the design standard and just cut it off after receiving the finished part. If you choose this option, make sure that the “sacrificial” part is equal to the minimum diameter for a “supported wire” as discussed above. The challenge is to meet the minimum design standards while minimizing total volume (which affects the cost of the part).

SketchUp

- Always draw in full size. Unlike most CAD drawings, there is no way to specify “HO” scale or “O” scale when using SketchUp. Thus, if you are drawing a door which is 32” wide by 80” high, start by drawing a rectangle which is 32” wide by 80” high. Once the part is complete, it will be reduced to your modeling scale later in the process. However, you also need to keep in mind the minimum dimensions of the part that you are drawing and the scale you will have it printed per the table on the previous page. So that door needs to be at least 1-1/8” thick.
- At the start of SketchUp, select “Choose Template” and then select “Simple Template - Feet and Inches” and then “Start using SketchUp”. This means that you can input accurate measurements with inches and feet abbreviations (“and ’). Dimensions can be entered in either even feet (4’) or inches (2 3/8) or a combination (4’ 2 3/8”). If you don’t add a foot or inch symbol, SketchUp will assume you are entering inches.
- The Large Tool Set, which has just about all of the tools that you will need, is under View/Tool bars and then click on Large Tool Set.
- SketchUp is very intuitive. For example, click on a drawing tool, hold the cursor on the edge of a circle, and then move toward the center of the circle and the cursor will lock to the center.
- SketchUp models circles as straight-line segments. After drawing a circle, use the Select tool (the arrow at the upper left corner of the Large Tool Set) and click the circle and then right click and choose “Entity Info”. Change the *Segments* from 24 to 96 to increase accuracy and smoothing. You can also use this dialogue box to change the radius of the circle if needed.
- Click on Window/Instructor to get specific directions on each tool selected.

Exporting a .stl File

- Keep in mind that your SketchUp files are **.skp** files. As you draw a part in SketchUp, you should upload that file to Shapeways often to test your work (especially when first getting started). Before you can do that, you will need to export the SketchUp file as a **.stl** file to upload the file to be 3D printed. The first step is to download a SketchUp extension from the SketchUp Extension Warehouse. Go to:

<https://extensions.sketchup.com/>

and then type *SketchUp STL* in the *Find Your Extensions* search box. Then click to download it. (When I did it years ago, it installed itself.) It will install under the SketchUp File menu. So you should have a new item in SketchUp under File which will be **Export STL...**

- Once a part is finished (or I want to upload it to test the results to date), export it using **File/Export STL**. I save the resulting .stl file in the root project folder to separate it from the SketchUp files. When you choose the menu **Export STL...** option, you may get a message “No objects selected. Export entire model?”. If so, select “Yes” and then select the “Inches and Binary” option.
- If you have more than one model that you are working on at the same time and what to check that one of them is okay, use the arrow tool to draw a “box” around one of the items and then right click the item and select “Hide”. You can later use Edit/Unhide and then close Last or All to show it again.

Netfab...the next step

- Keep in mind that you (hopefully) drew your part in full size. In order to upload it to Shapeways, it needs to be converted to millimeters and your scale (such as HO). The default Shapeways

upload is metric. So before uploading it to Shapeways, you need to 1) convert it to metric and 2) rescale it to your modeling scale.

- When I began using SketchUp and Shapeways, there was a free program called Netfabb to do both of these functions and also optimize the result. Several years ago, the program was sold to Autodesk (which markets AutoCad) and the price for that once-free program is now \$1,000 per year! But there are alternatives.
- Alt A. – Netfabb is still my preferred option for converting to metric and reducing the file to my modeling scale since it also corrects small problems. According to a press release from Autodesk which owns now Netfabb:

“When we released the latest update of Netfabb 2017, we changed the way you can get the basic version of Netfabb. We unfortunately did not include that detail in our original announcement, and we’d like to use this post to update our users and clarify some points. Instead of downloading Netfabb Basic as a separate product, all customers have to do now is download the free Netfabb Trial. For the first 30 days, users will have access to all the features of Netfabb Premium, including advanced packing, support structures and support for metal additive systems. When the trial expires, the software will continue to run with the same functionality that was previously Netfabb Basic. For most users, it’s still the same basic Netfabb you know and love and can be used to preview, fix, and analyze STLs and much more. “

You can download a Windows version of Netfabb at:

<https://www.autodesk.com/products/netfabb/free-trial>

- Alt B. – I have the free Windows version of Netfabb —email me and I can email it to you.
- Alt. C – The .stl file which can be exported to SketchUp is usable by Shapeways. To use this option:
 - First **Save As** your file with a unique name such as HO Window HO.stl. Then rescale it to your scale by using Edit/All to select the entire file. Rotate your view so that you can see the entire model including two opposite corners, one at the top and the other at the opposite bottom. Then use the Scale tool and point at one corner in the top of one end and a dotted line will “suggest” that you want to reduce the scale of the entire model evenly. Click on that corner and begin dragging toward the opposite bottom corner. Then type in your scale ratio such as 0.0115 for HO (which is 1/87 to four places).
 - That takes care of the need to rescale your project. When you upload that file to Shapeways, you need to select the option that it is in inches and not metric.

Using Netfabb

- Here is the process for using Netfabb:
 - Open the exported SketchUp . stl file in Netfabb.
 - From the drop down menu, select **Part/Convert Units** and then choose the **Inches to mm (scale up by 25.4)** menu item to convert the part from inches to millimeters.
 - From the drop down menu, select **Part/Scale** command and use the *Scale Factor* based on the desired final scale (you only need to input it in one of the X/Y/Z input boxes.)

Input the scale as a decimal; the number to be inputted is equal to 1 divided by your scale factor (1/87 for HO, 1/48 for O, etc.) For example:

- For N scale input *0.00635*
- For HO input *0.0115*
- For S scale input *0.0156*
- For O scale input *0.0208*
- Input the scale factor in one of the input boxes and select **Scale**.
- From the drop down menu, select the **Part/Export part/As STL** command.
- If the software finds some errors, click the **Optimize** button and then click on the **Export** button.
- I save that .stl file with the name that I want it to appear in Shapeways, i.e., the final part name.

Materials

- I have always ordered my parts to be printed in Smoothest Detail Plastic. It is a little more expensive than Smooth Detail Plastic but the surface texture of the part is important to me.

Shapeways Tips

- There are a number of other firms which provide rapid prototyping services. But so far, I have been satisfied with Shapeways (<http://www.shapeways.com/>) since they are totally committed to small designers with no minimum purchase and the built-in ability for you to sell the parts you design if you so choose.
- To use Shapeways, you will first need to establish an account. Click on **Join** to set up an account where you can upload parts and order items.
- Once you have an account, Shapeways will automatically log you in each time to visit the website.
- The Shapeways website isn't that intuitive. Once you have an account, log in (if necessary). If you want to upload a new model, click on the "Choose a 3D model or drag it here"
- If the part is small and not complex, it will be shown and you can click on the "3D Print" button and the next screen will show it in 3D. Use the mouse to look around, over, and under the item.
- If the part is complex, you may not see it appear. But check your email program and there should be an email from Shapeways with a link ("Order your model") to the uploaded part.
- The size of the uploaded part in MM (millimeters) is listed under the image of the uploaded part. Click on the MM to change to inches if desired.
- Click on the underlined TOOLS next to the file name and choose "Open in 3D tools". (Note: if you notice a problem with your upload, you can keep this program open and fix the issue. You can then click on "Update" rather than starting over.)
- The "Open in 3D tools" will take you to a page which where the Shapeways computers will test your part to ensure that it can be printed. The default material is always White Natural Versatile Plastic even if you selected your chosen material in the previous screen. (I have complained about this to Shapeways but nothing was done.) You will not get correct testing unless you click on the arrow next to the material and choose the material you anticipate using.
- This page will give you a larger view of your part. Click on the right arrow above the part to turn off the text to have more space to view your part. Make sure that everything is there and openings are see-thru. Carefully examine your model for flaws and rotate the part in all directions. When I first started using SketchUp, I discovered a number of times that a part which

looked fine in SketchUp and even exported fine from Netfabb, had flaws once it was uploaded to Shapeways. If you see problems, go back to SketchUp and fix it. You can then use **Update** in the first screen in Shapeways to upload the repaired file. (Note: files are automatically saved...there is no **Save** button.) For some parts, I uploaded the part, found a problem, fixed it, and continued to draw the part only to find another problem. Upload often!

- If a test finds a problem, click on that item and the computer will give you an indication of what it found.
- On complex parts look very carefully at “holes” in the part where they should not be. That means that something is causing problems for Shapeways even though your part looks fine in SketchUp.
- If everything looks okay and all of the tests passed, you can select the Orientation if desired. A help screen will give you information about orientation choices.
- Click on “Back to Model” to return to the previous screen.
- Cost is based on a print time plus the volume of the part based on the selected material. Shapeways suggests that you minimize the volume whenever possible by adding holes in the bottom of larger parts where they won’t show or affect the part. For small parts, put multiple parts on a sprue to reduce the handling cost.
- If you want to order one of your parts, click on Fine Detail Plastic. You will then be given the choice of Smooth or Smoothest and the price difference. The “Add to cart” will take you to the payment and summary page. There are options for faster manufacturing time and faster shipping. All payments are made through PayPal.

After You Receive Your Parts

- If parts from Shapeways are somewhat sticky, it might be due to incompletely cured material as a result of insufficient UV curing of the parts. Solve that problem by leaving the parts in the sun for a couple of days.
- I clean my 3D printed parts by first cleaning them with Simple Green Cleaner followed by a quick rinse in warm, clean water. I then dip the parts in 91% isopropyl alcohol and then let them air dry.
- If the surface of the print is too rough, primer the parts with PlasticKote automobile Spot Filler & Primer ([Amazon carries it](#)). **Once dry**, sand the model lightly. I paint with Floquil and have only once had a problem with the finish coat not adhering to the part. I don’t have experience using acrylic paints over the primer.