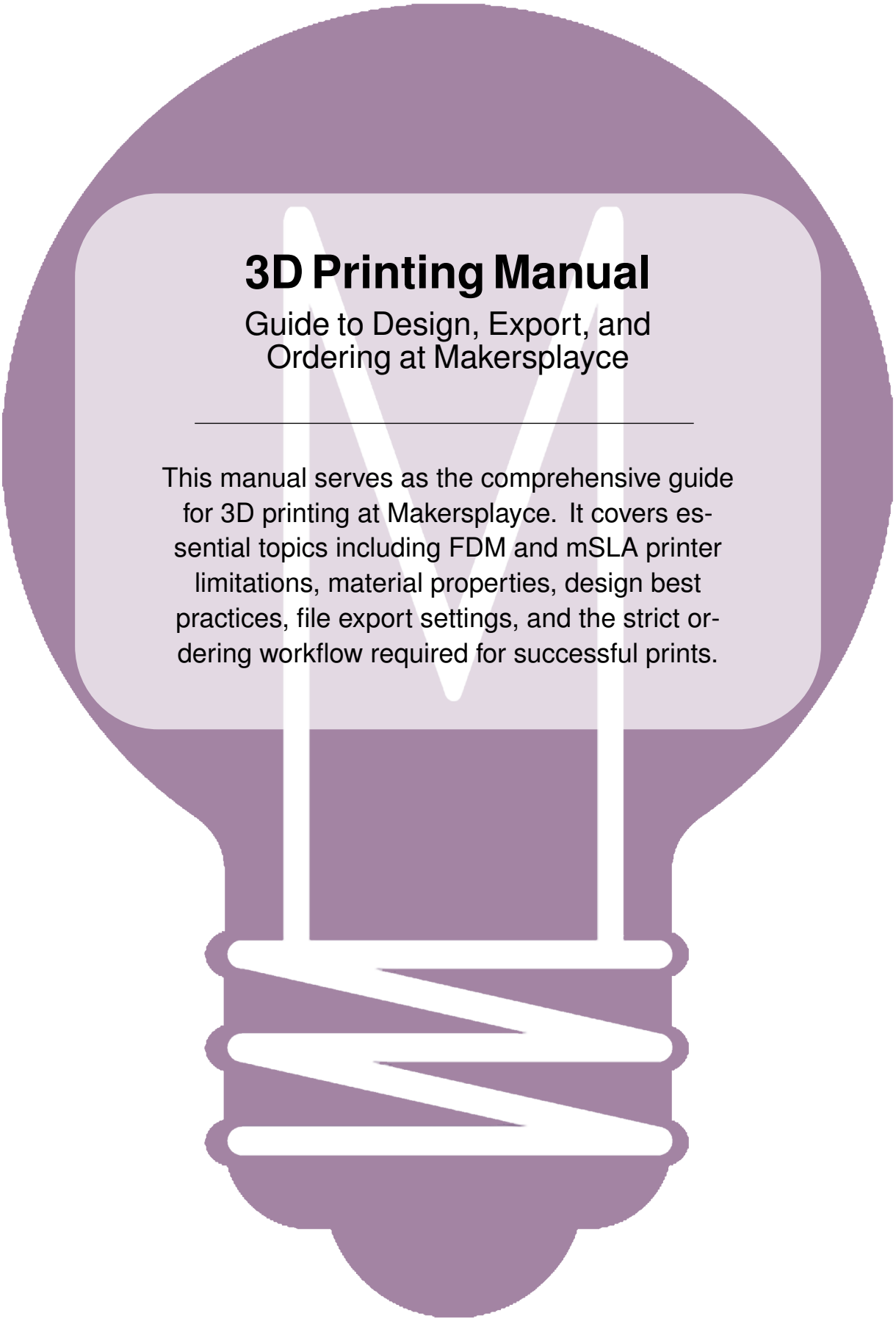


3D Printing Manual

Guide to Design, Export, and Ordering at Makersplayce

This manual serves as the comprehensive guide for 3D printing at Makersplayce. It covers essential topics including FDM and mSLA printer limitations, material properties, design best practices, file export settings, and the strict ordering workflow required for successful prints.

Checklist

Important: Only use this checklist if you have read the complete manual before.

1. Design Self-Check

Before ordering, check your CAD model for these common issues:

- **Wall Thickness:** Are all walls at least **0.8mm** thick? (Rec. >1.2mm).
- **Tolerances:** Did you leave **0.1mm - 0.3mm** gap for fitting parts?
- **Flat Bottom:** Does the object have a flat surface to stand on the print bed?
- **Chamfers:** Did you use chamfers (45°) instead of fillets?

2. Economy & Logic Check

3D printing is slow and expensive. Ask yourself:

- **Invalid Objects:** Are you printing simple cylinders (Axles), flat plates, or simple boxes? **Use the Laser Cutter, Lathe, or Wood instead.**
- **Standard Parts:** Don't print nuts, bolts, or washers. Buy them.
- **Material:** Do you really need ABS, ASA, PAHT-CF, PETG or TPU? Justify if yes!

3. Maximum Build Volumes ($W \times D \times H$)

- **Bambu Lab X1E/P1S (FDM):** $250 \times 250 \times 250$ mm
- **Bambu Lab H2S (FDM):** $340 \times 320 \times 340$ mm
- **NEXA XiP (mSLA):** $190 \times 120 \times 210$ mm

4. Files, Materials & Color

- **File Types: .STL** only. No .3MF/.STEP. Export in **Millimeters**.
- **Color:** We print in **Black or White** by default. Other colors require justification.
- **Batching:** Group ready parts into **one single order**.
- **Spam:** Don't send several orders per day
  - You **can** mix FDM materials (PLA, PETG, TPU, ABS, ASA) in one order.
  - **Exception:** mSLA (Resin) parts must be in a **separate order**.
  - **Zip Files:** We prefer when you compress multiple STLs into one **.zip** file.

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1 Intro (What is 3D Printing)

3D printing, also known as additive manufacturing, is a process that creates three-dimensional objects from a digital model by adding material layer by layer.

We have two types of 3D Printers: FDM and mSLA.

1.1 FDM: Fused Deposition Modeling

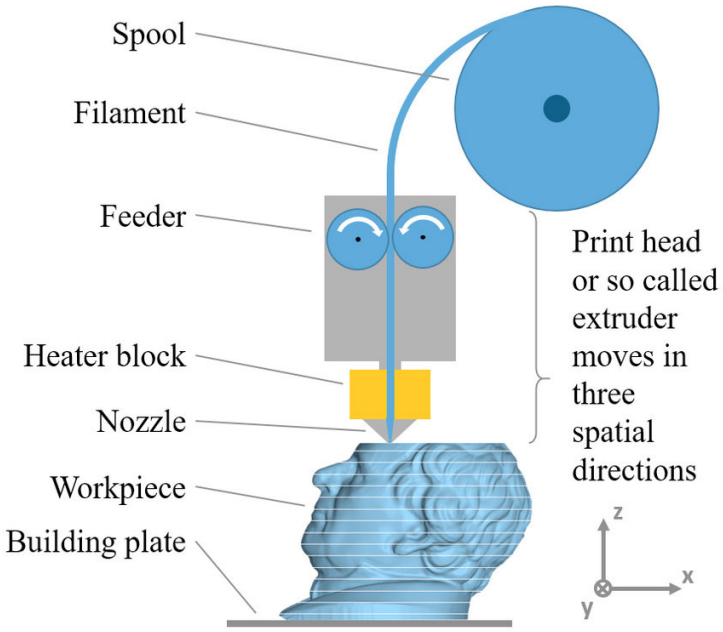


Figure 1: FDM Diagram

FDM printing is relatively simple in theory. A strand of plastic (filament) is pushed through a heated nozzle. The heat melts the plastic, making it pliable. The printer moves in X and Y directions to deposit the material in the desired shape. The build plate then lowers, and the next layer is added on top.

Glossary of Terms

Spool: The reel holding the raw filament material.

Filament: The plastic material wire used for printing.

Feeder: The motor mechanism that pushes the filament.

Heater Block: The component that melts the plastic.

Nozzle: The tip where melted plastic exits.

Build Plate: The surface where the object is printed.

1.2 mSLA: masked Stereolithography

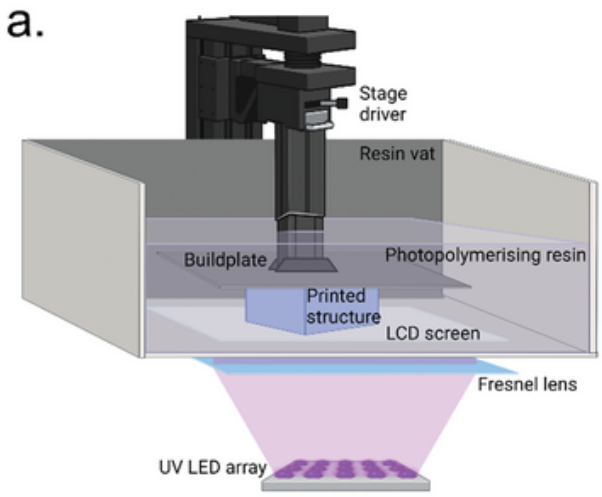


Figure 2: mSLA build

mSLA is a resin 3D printing technology that uses a UV LED array and an LCD screen to cure layers of photopolymer resin.

Unlike FDM, which draws lines, mSLA cures an entire layer at the same time. The LCD screen acts like a digital mask (stencil), blocking UV light in some areas and letting it through in others. The light that passes through hardens the liquid resin instantly in the shape of that layer. This makes the process very fast and independent of how many parts are on the plate.

Glossary of Terms

Resin Vat: The tank holding the liquid photopolymer resin.

LCD Screen: Masks the light to create the shape of the layer.

UV LED Array: The light source that cures (hardens) the resin.

Buildplate: The platform that lifts the object out of the resin.

2 3D-Printer Limits

Every production method has its pros and cons. This chapter focuses mainly on the limits of 3D printing that you should be aware of.

2.1 Overhangs

An overhang is any part of a model that extends outward without direct support from the layer below. If this angle exceeds 60°, the material is likely to sag or deform due to gravity.

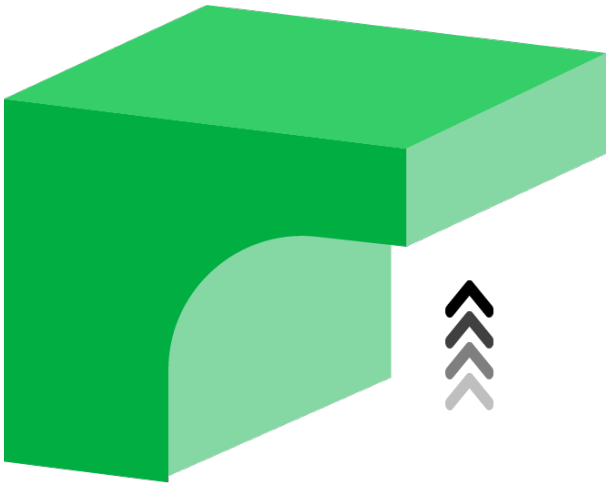


Figure 3: Illustration of an overhang

During printing, supports act as a safety net beneath overhangs, providing stability for the upper layers. Supported surfaces have a rougher finish and the supports add an additional point of failure.

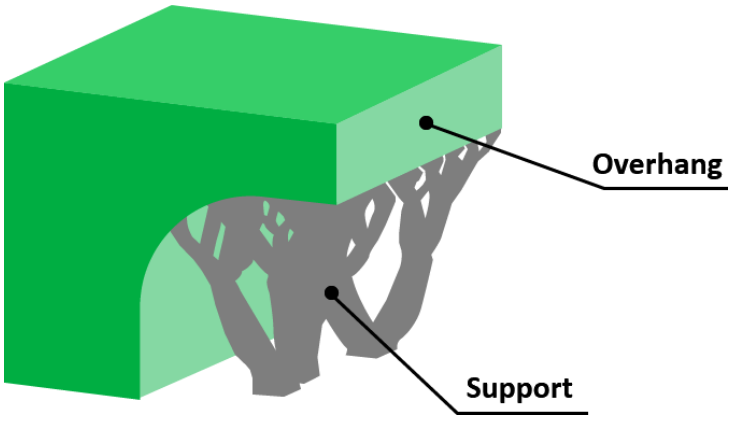


Figure 4: Overhangs supported by material

2.2 Volume

The size of parts that a 3D printer can produce depends on the printer's build volume. At Makersplayce, we have multiple different printers, which all have different dimensions.

Table 1: Available Printers

Printer	Type	Amount	Build Volume (mm) (W x D x H)
Bambu Lab P1S/X1E	FDM	21	$250 \times 250 \times 250$
Bambu Lab H2S	FDM	3	$340 \times 320 \times 340$
NEXA X1P	mSLA	2	$195 \times 115 \times 210$

The parts for your project cannot exceed these dimensions. You can split parts into different pieces with dovetails and glue them together.

Note: We do not recommend this, as splitting parts reduces structural integrity (rigidity) and alignment precision.

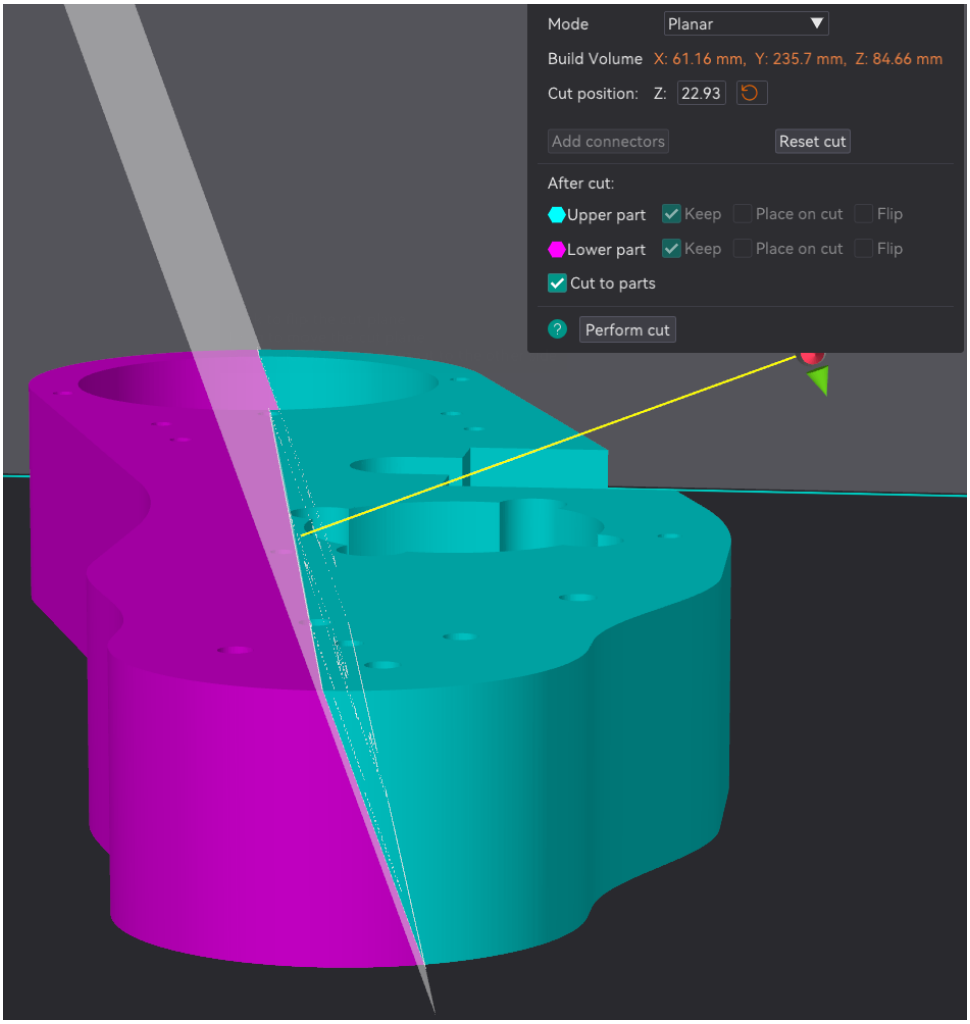


Figure 5: Using a cut tool to split large models

2.3 Precision

Due to the nature of printing, there is a limit to how detailed parts can be.

2.3.1 FDM Details (Nozzles)

- **0.4mm Nozzle (Standard):** We use this for 95% of orders. It offers the best balance between print strength, speed, and detail.
- **0.2mm Nozzle (High Detail):** We have printers equipped with smaller nozzles for extremely fine details. **Note:** Only request this if absolutely necessary. It significantly increases print time and the risk of print failure.

2.3.2 FDM Tolerances

You should keep tolerances in mind, especially when parts need to fit together. For FDM printing, the general guideline is to use:

- **+0.1mm** for press-fits
- **+0.2mm** for perfect-fits
- **+0.3mm** for loose-fits



Figure 6: Visualizing Tolerances (Pin and Hole)

2.3.3 mSLA Precision

For our resin printers, the resolution is limited to **50 microns (0.05 mm)**. While resin printing is very precise, this limit is determined by the physical pixel size of the LCD screen inside the printer.

3 Material Properties

Understanding the properties of the material is crucial for the longevity and functionality of your print. Below is a comparison of our standard FDM materials: PLA, PETG, TPU, and PAHT-CF (Carbon Fiber Nylon).

3.1 Color Policy (Standard vs. Special)

Standard Colors: Black & White

We strictly print in Black or White by default.
We stock large quantities of these standard colors. Unless you specify a valid reason otherwise, your part will be printed in one of these two.

Special Colors: We have a limited supply of other colors (Red, Blue, Green, etc.). You must provide a **justification** in your order comments if you strictly require a specific color.

3.2 Material Cost

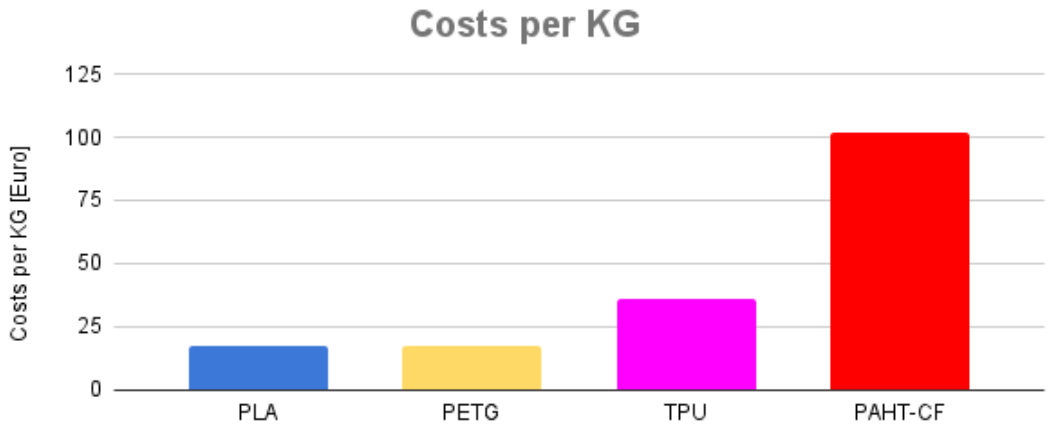


Figure 7: Cost per KG

PAHT-CF Cost Warning

PAHT-CF is approx. 5x the price of PLA.
You **must** justify why you need this material in your order comments. If the high strength or temperature resistance is not strictly required for your application, we will decline the order.

3.3 Stiffness (Young's Modulus)

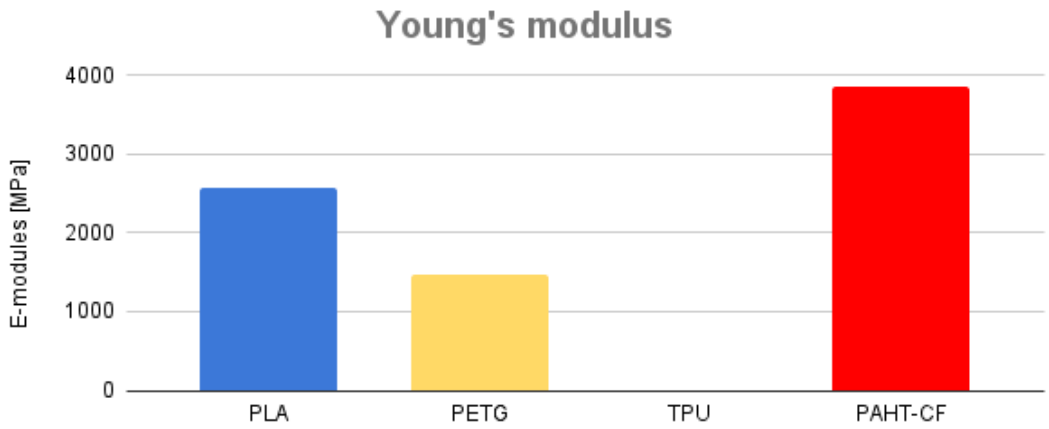


Figure 8: Young's Modulus (Stiffness)

Explanation: Young's Modulus measures how much a material resists elastic deformation.

- **PAHT-CF** is extremely stiff and will hold its shape under load.
- **PLA** is actually quite stiff, but brittle.
- **TPU** has a very low modulus, meaning it is flexible and easily deform.

3.4 Tensile Strength

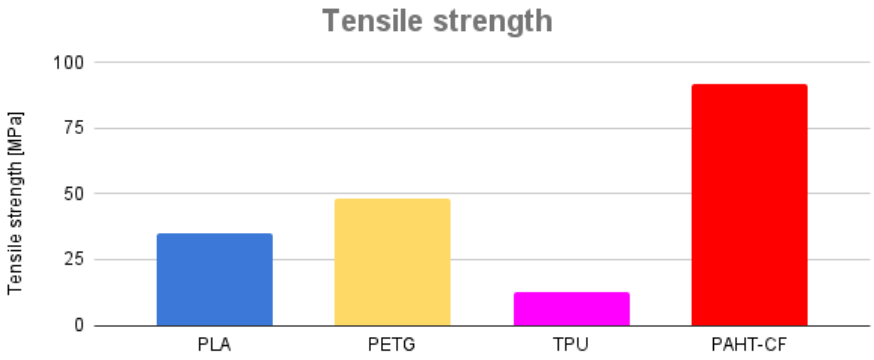


Figure 9: Tensile Strength

Explanation: This measures the force required to pull a material apart until it weakens. **PAHT-CF** is by far the strongest option for load-bearing parts. TPU appears weak here because it stretches rather than resisting the pull force.

3.5 Deformation (Elongation at Break)

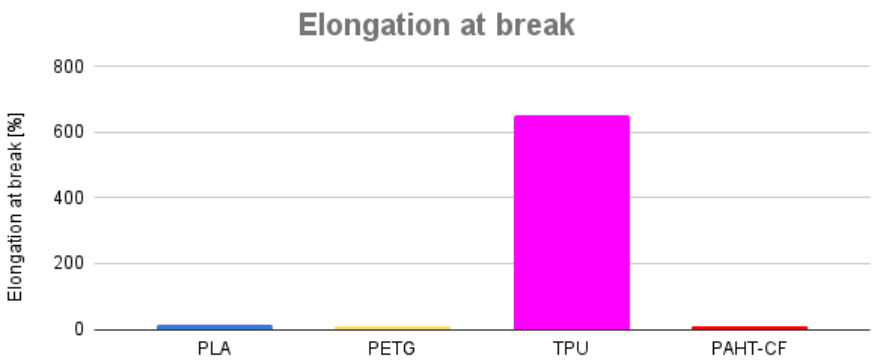


Figure 10: Elongation at Break

Explanation: This measures how much a material can stretch before snapping.

- **TPU** is rubber-like and can plasticly deform over 600% of its original length.
- **PLA and PAHT-CF** have very low elongation, meaning they are rigid and tempted snap if forced to stretch.

3.6 Impact Strength (Toughness)

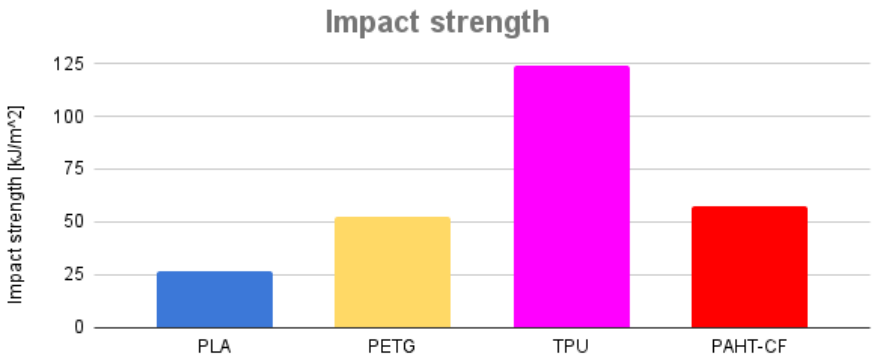


Figure 11: Impact Strength

Explanation: This determines how well a material handles sudden shocks (like being dropped).

- **TPU** absorbs energy excellently and is virtually indestructible by impact.
- **PLA** is brittle and tends to shatter.
- **PETG** offers a good middle ground for everyday parts. Its slightly lower stiffness makes it handle shocks better.

3.7 Density (Weight)

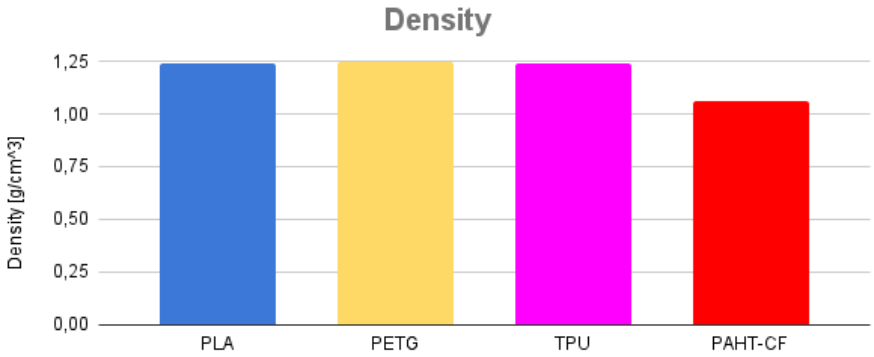


Figure 12: Density

Explanation: While PLA, PETG, and TPU have similar densities, **PAHT-CF** is notably lighter (around $1.05 g/cm^3$). This makes it an excellent choice for applications where high strength-to-weight ratio is critical, such as drone parts or automotive components.

3.8 Temperature Resistance

The Glass Transition Temperature (T_g) is the point where a plastic begins to soften and lose its structural shape.

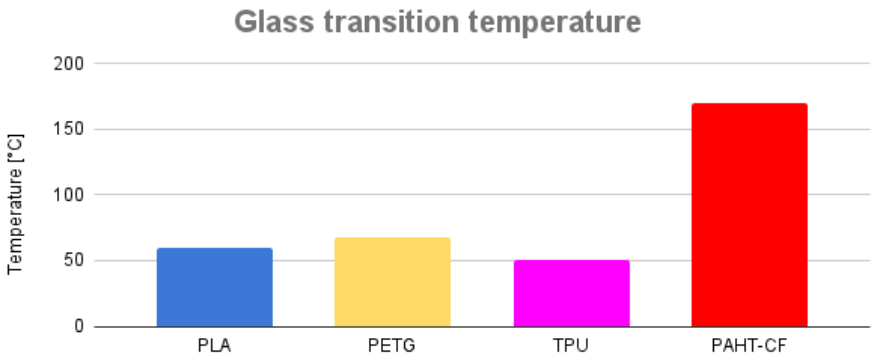


Figure 13: Glass Transition Temperature

Explanation:

- **PLA & TPU:** Low heat resistance. Do not use for parts that will stay in a hot car during summer (approx. 60°C limit).
- **PETG:** Moderate resistance (approx. 75-85°C).
- **PAHT-CF:** Excellent heat resistance. It maintains its integrity at much higher temperatures (approx. 170°C), making it suitable for functional parts near engines or electronics.

3.9 mSLA Material (Resin)

For our mSLA printers (NEXA XiP), we primarily use **xModel35** resin.

There is no specific recommendation to follow for students because our staff decides how to print it to ensure the best results. However, if you are experienced with mSLA printing on Nexa machines, you are welcome to include specific requests or settings in your order comments.

4 Designing for 3D Printing

3D printing is an impressive tool to design almost anything. However, due to the limitations of FDM printing, specific object types yield poor results. Therefore, we will decline requests to print the following:

4.1 Invalid objects

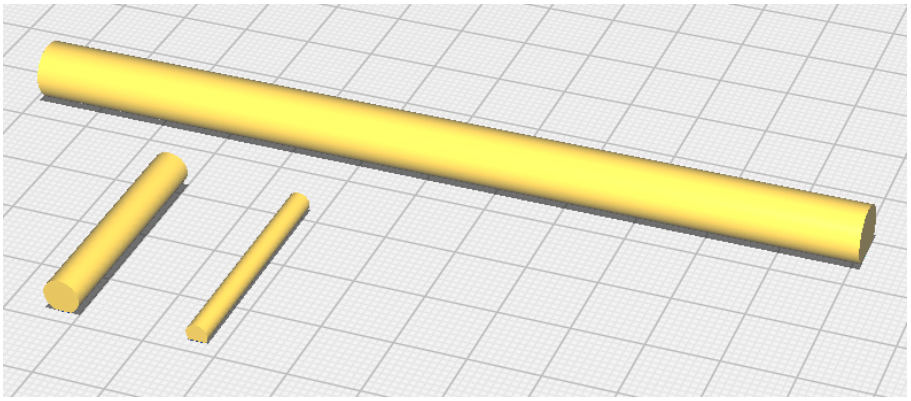


Figure 14: **Surface Finish/Strength:** 3D printed plastic axles have high friction and are significantly weaker than metal. They will often snap under torque.

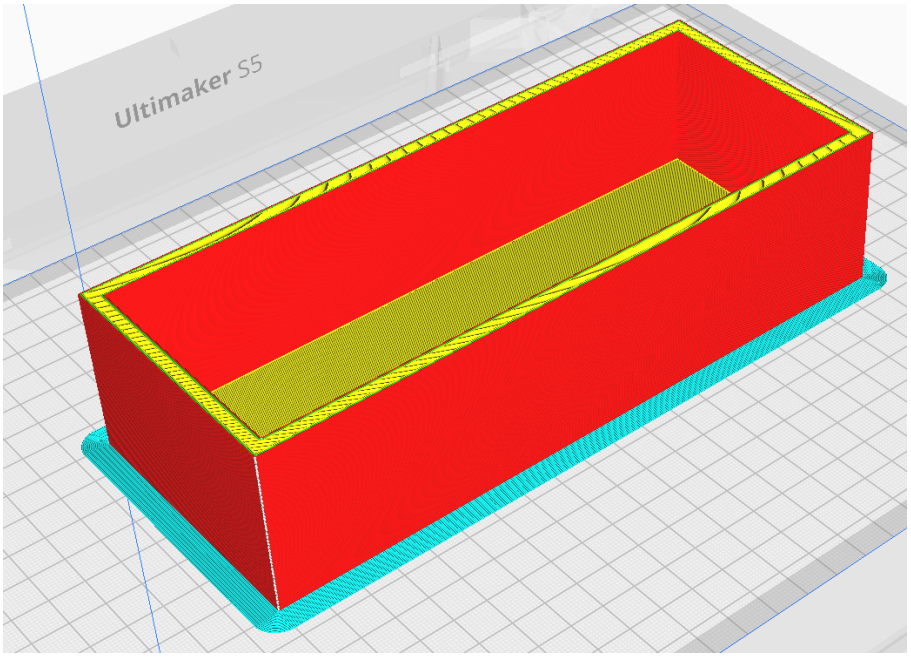


Figure 15: **Inefficient:** Printing large, solid boxes wastes massive amounts of time and material. It is faster, cheaper, and stronger to build these from wood or acrylic.

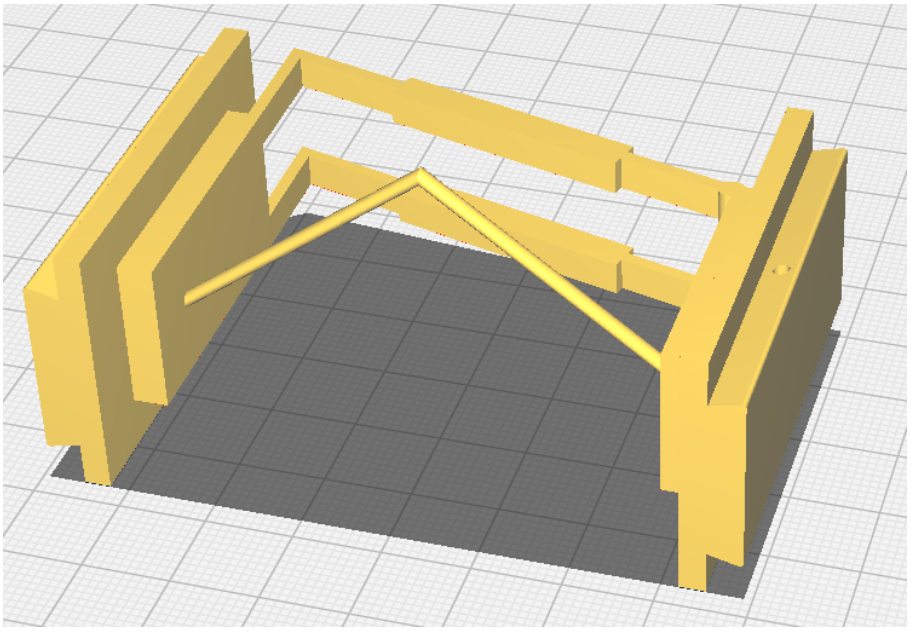


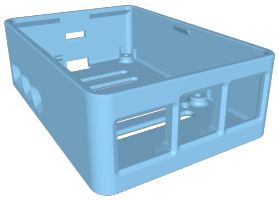
Figure 16: **Too Fragile:** Geometries are too thin to support their own weight or function.

Strict Policy: We do not print weapons or functional parts of weapons.

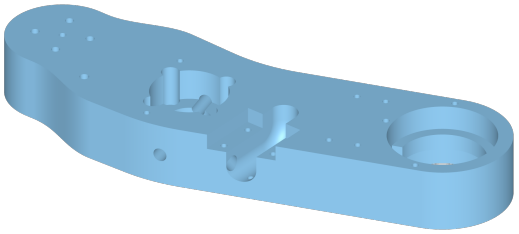
Standard Parts (For Example): Think like an engineer; do not reinvent the wheel for your projects. It is inefficient to design and print a standard bracket when a metal version is readily available, cheaper, and significantly stronger.

4.2 Valid objects

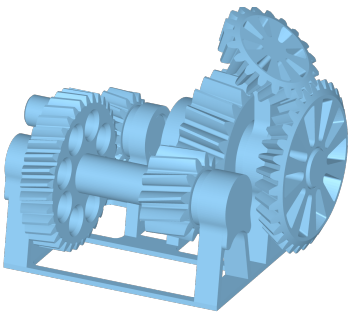
3D printing shines when creating objects that are tailored to specific functional needs. We print a big variety of parts and want to give you some examples of proper printing design.



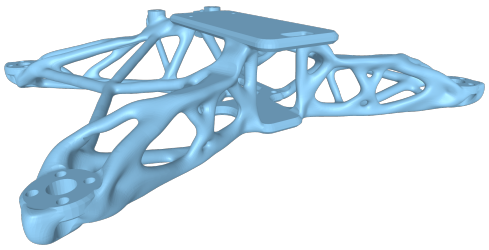
1. Custom PCB Enclosures
Non-conductive housings designed to perfectly fit custom electronics, batteries, and connectors.



2. Complex Robotic Parts
Brackets, end-effectors, or mounts with complex internal geometries or lightweighting requirements that are hard to machine.



3. Functional Mechanisms
Gears, linkages, and compliant mechanisms. This allows for fast prototyping to verify kinematics and functionality.



4. Organic Structures
Shapes optimized for weight reduction that are almost impossible to create with subtractive manufacturing.

Figure 17: Examples of valid engineering applications for 3D Printing

Prototyping Cost Warning

Do NOT use PAHT-CF for initial prototypes.
Due to the high cost of Carbon Fiber Nylon, you must verify your fit, form, and function using inexpensive materials (like PLA) first. Only request PAHT-CF for the final, verified iteration (and if really needed).

4.3 Improvements

Many prints can achieve significantly better quality if designed specifically for 3D printing.

- **Flat Bottom:** Design your object with at least one large flat surface to adhere well to the print bed.
- **45 Degree Rule:** Avoid overhangs steeper than 45 degrees.
- **Elephant's Foot (Chamfers):** The first few layers of a print are often squished slightly wider than the rest (Elephant's Foot). Use a small **Chamfer (45-degree angle)** on the bottom edge to compensate for this. **Do NOT use Fillets** on the bottom, as they curve upward and often cause the print to warp.

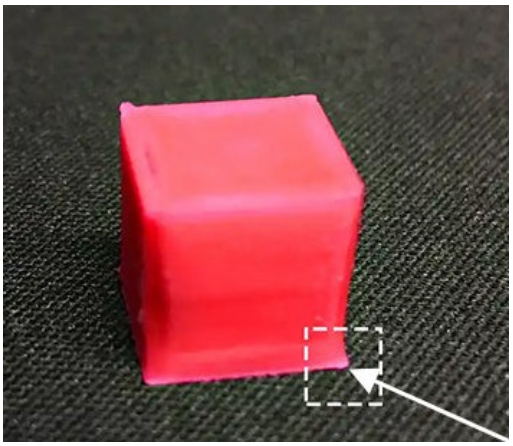


Figure 18: Elephant's Foot: Use Chamfers to prevent this.

- **Vertical Pins:** Vertical pins sticking up from a print are weak due to layer lines. Always add a **Fillet** at the base of the pin where it meets the main body. This distributes the stress and prevents the pin from snapping off easily.

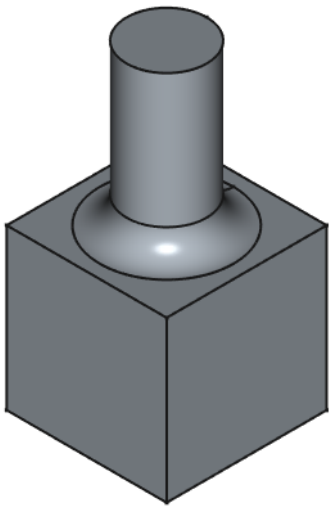


Figure 19: Add fillets or chamfers to the base of vertical pins for strength.

- **Teardrop Holes:** For horizontal holes, use a teardrop shape to avoid the need for supports inside the hole.
- **Threaded Inserts:** To prevent plastic from cracking when inserting screws, use chamfers around holes or design them to accept metal threaded inserts. **Note:** If you plan to use these, please mention the required **wall diameter** in the order comments.

Table 2: Available Heat-Set inserts

Metric Size	Hole ∅ (mm)	Depth (mm)	Wall Thickness (mm)
M2	3.3	4.0	1.5
M3	4.0	6.0	1.6
M3.5	4.8	7.0	1.8
M4	5.6	6.0	2.1
M5	6.4	9.5	2.6
M6	8.0	12.5	3.3

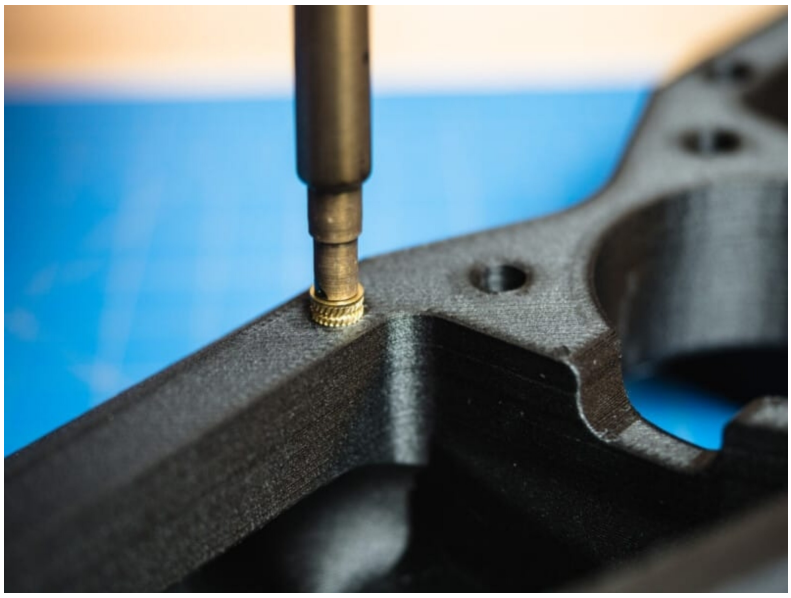


Figure 20: Heat-Inserts

5 Export

5.1 File type

We strictly accept the following format:

- **.STL** (Standard Triangle Language).

Why STL Only? Other formats like **.3MF, .STEP, and .OBJ** are **NOT accepted** as they often exceed the file size limits of our ordering system (Trello) or cause compatibility issues with our slicers. Please strictly use STL.

Note: Please ensure your file is exported in **Millimeters**.

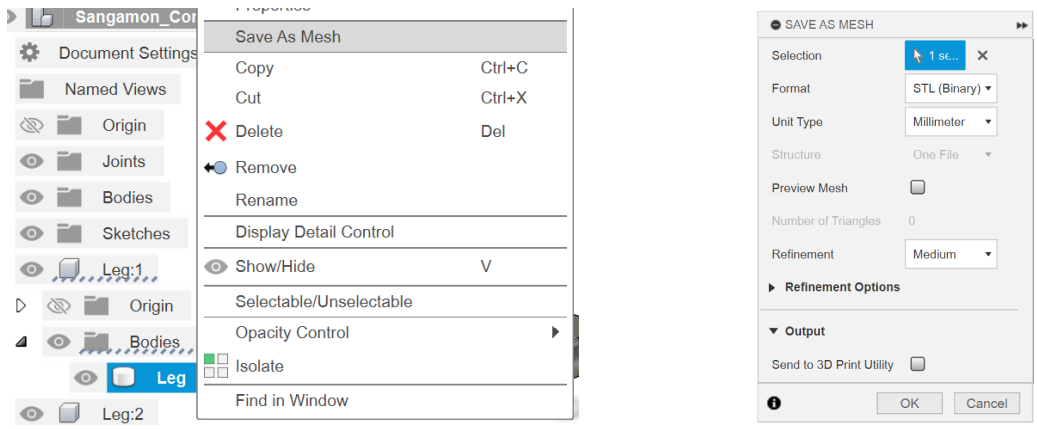
5.2 File Compression

If your order consists of multiple parts, please group them together.

- **Archive Format:** You may compress multiple .stl files into a single **.zip** archive.
- **Software:** We strongly recommend using **7-Zip** (free & open source).
- **Warning:** Avoid **using WinRAR** or .rar files, as they often cause compatibility issues with our system.

5.3 Exporting in Fusion 360

Right click on the body you want to export and hit 'save as mesh'. Specify the format as Binary STL and hit 'ok'.

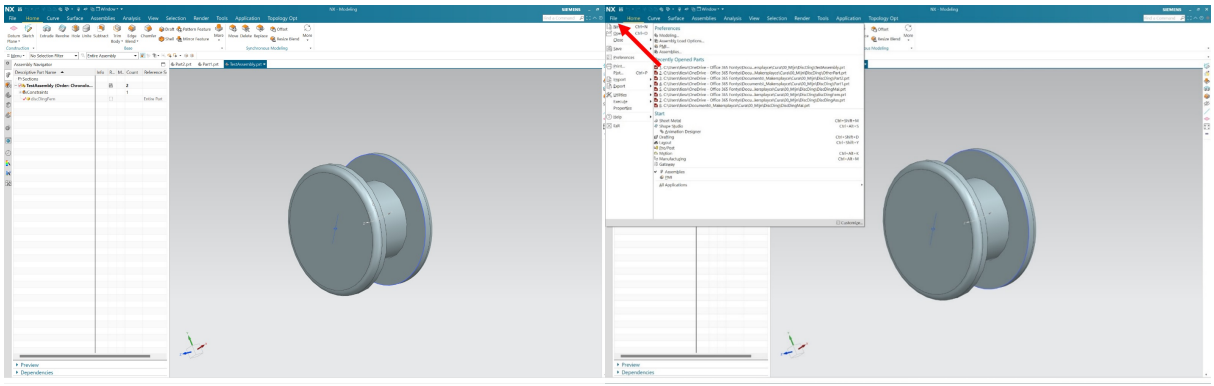


(a) (b)

Figure 21: Exporting in Fusion 360

5.4 Exporting in Siemens NX

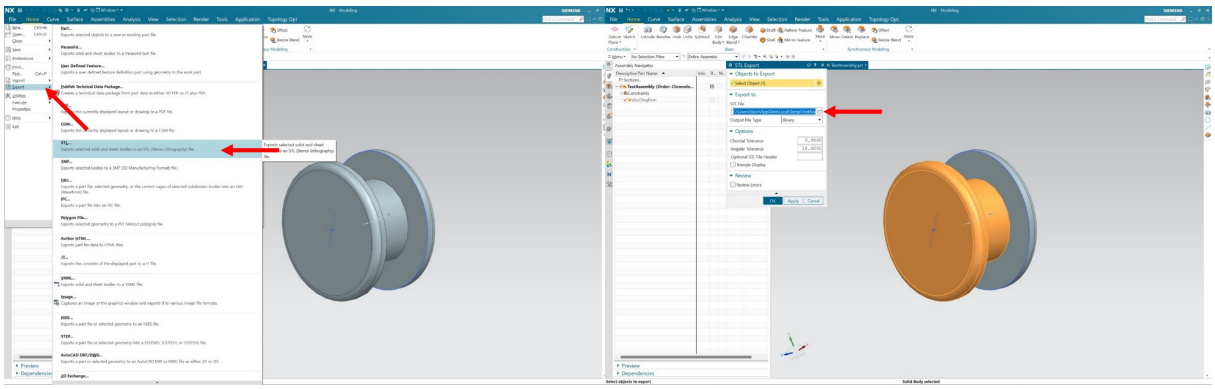
Exporting single bodies in NX is straightforward. Go to 'File' in the top left corner, then select 'export' and choose 'STL'.



(a) (b)

Figure 22: Exporting bodies in Siemens (1).

After selecting the correct file type, you will be able to select the part(s) you want to export. These will be highlighted orange after clicking on them. Then finally select the location where you want it to be saved.

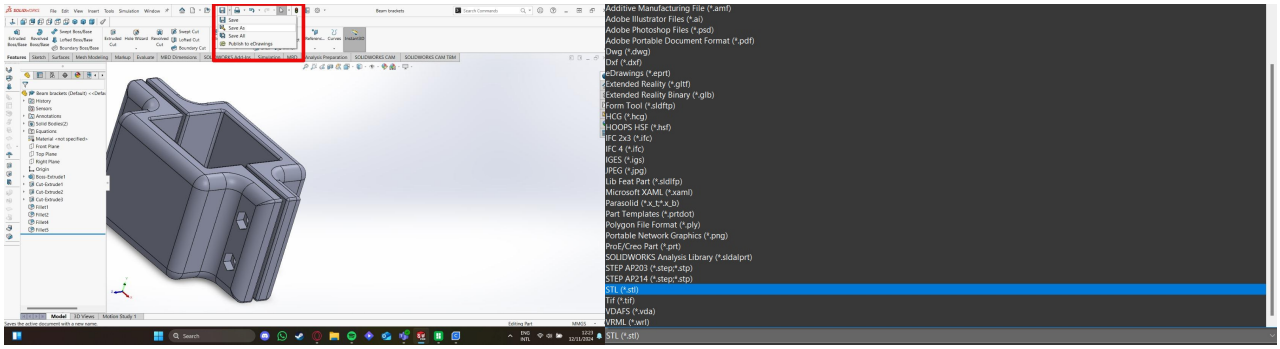


(a) (b)

Figure 23: Exporting bodies in Siemens (2).

5.5 Exporting in Solidworks

To export an STL in Solidworks you have to go to the individual part. Then simply save as an STL.



(a) (b)

Figure 24: Exporting in Solidworks.

6 Order Processing & Pickup

6.1 Printing

We will slice and print your parts using our own optimized settings to ensure success. If you have specific requirements, you must request this in the comments of your order.

6.2 Pick up

You will receive an email notification when your print is finished. The parts are placed in a pickup cabinet and can also be picked up outside of our opening hours.

Please check your order in Trello to know how far the process is.



Figure 25: Pickup-Cabinet

6.3 Removal

We store finished orders for **4 school weeks (excluding holidays)**. If they are not picked up by then, they will be recycled.

6.4 Post processing

Post-processing tools can be found at Makersplayce.

- **Support Removal:** We remove bulk support; fine removal is your responsibility.
- **Smoothening:** Sandpaper, Dremel, and Scotch-Brite are available.
- **Painting:** We have spray paints available. Please use them **exclusively** in the workshop paint booth. Talk with the Staff of the workshop before usage!



Figure 26: Workshop Paint Booth

- **Threaded Inserts:** We provide the inserts and a designated tool with the correct tips for heat-setting them. Do NOT use normal soldering irons for heat-inserts!

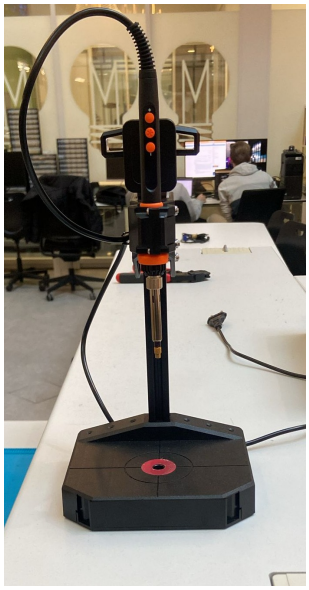


Figure 27: Heat-set tool and inserts

Questions?

Is anything still unclear? Feel free to come by and ask in person or send us an email: makersplayce@fontys.nl