Manual for 3D Printing

TubeN

May 2024

1 Introduction

We used the printer Original Prusa MK3.9 with a 0.4mm nozzle, and the material used is PLA. In this manual, we will discuss potential issues that may arise during actual 3D printing process and provide recommended solutions by using examples [a], [i], [u], and [o]. It is important to note that this is only a reference guide; different situations may occur during actual operations, and it would be better to seek advice from professionals based on specific issues.

2 Continuous Tubes

2.1 Printing Orientation

Using [u] as an example, this tube has a total length of 20cm, which exceeds the print area and is prone to tipping over in a vertical orientation. When printing it horizontally, the tube may split along the layer lines (see Figure 2). Therefore, we recommend printing tubes in a leaning orientation, lowering the printing speed, and adjusting the layer height to enhance the strength and smoothness of the tube.

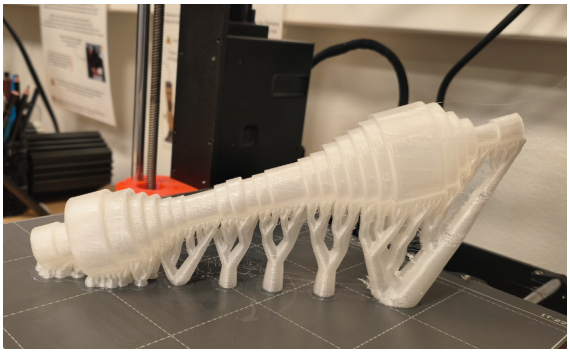

Figure 1: [u] with organic support

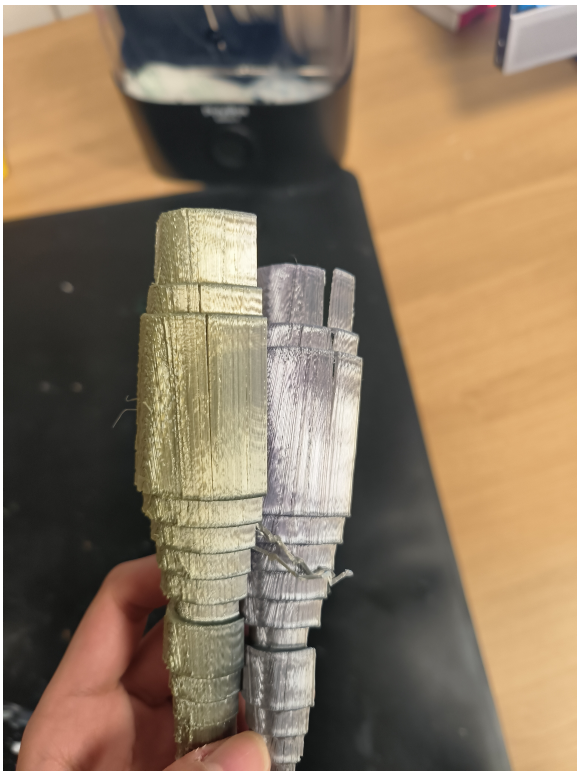

Figure 2: Split along layer lines

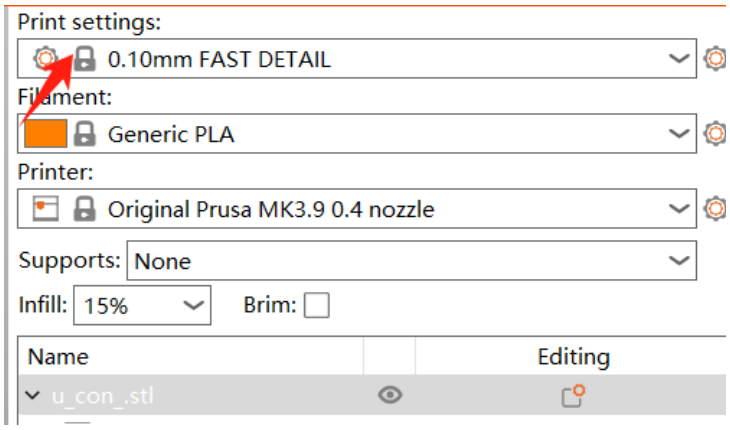

Figure 3: Setting layer height

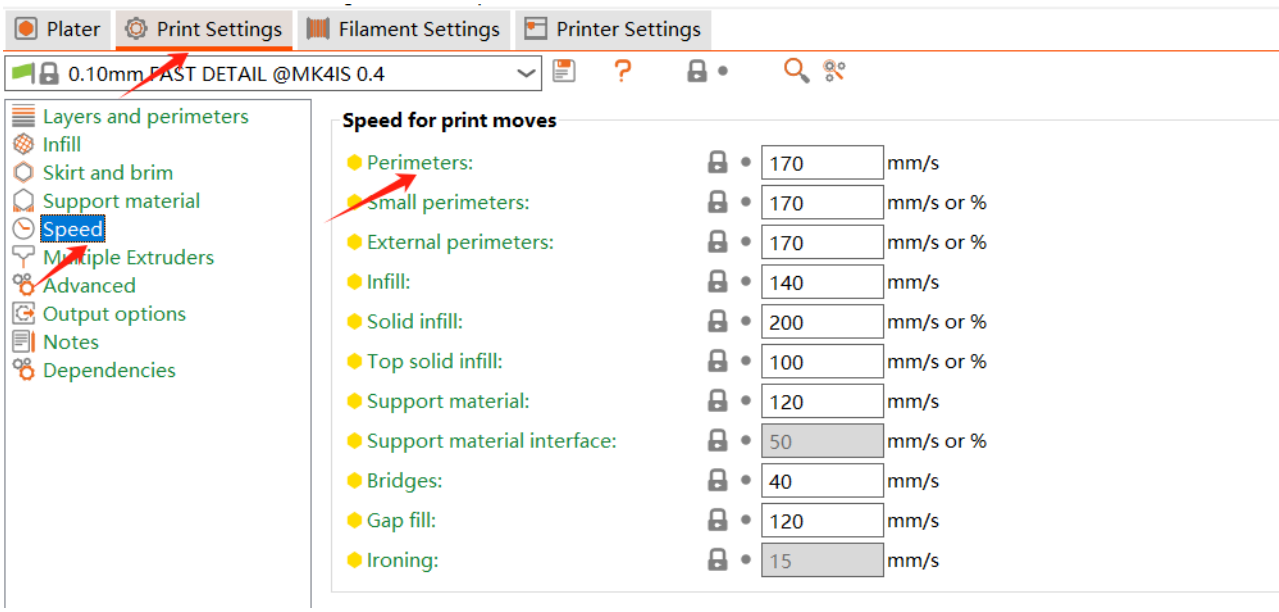

Figure 4: Printing speed

2.2 Adding Support

In PrusaSlicer 2.7.2 software, there are various methods to add supports that help improve printing stability. We have tried different support methods and found that the best option is selecting "Support on build plate only + Organic support". This method reduces unnecessary material usage and printing time, while also optimizing the distribution of the support structure. It improves print quality and makes it easier to manually remove the supports afterward.

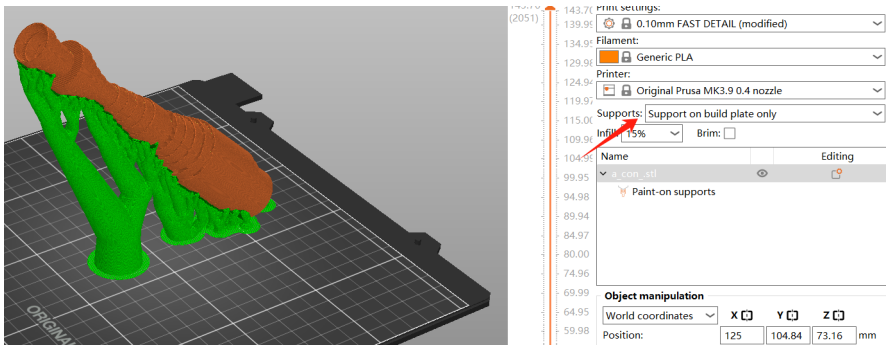

Figure 5: Support on build plate only

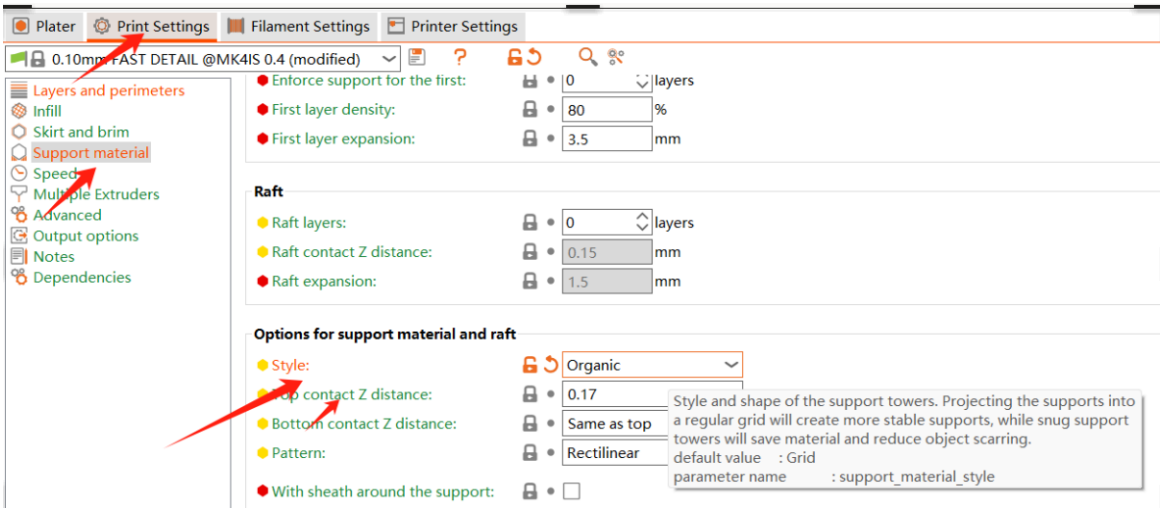

Figure 6: Organic Support (It needs to set "Support on build plate only" first, then change the support type to "Organic" in the print settings.)

It would be useful to use the "Contact Z distance" function to adjust the vertical distance between the support and the model based on specific needs. Smaller distance can provide better support but may be more difficult to remove. Pay attention to adjusting the leaning angle of the tube to prevent the tree supports from extending into the inside of the tube, which can cause difficulties in support-cleaning. If adjusting the leaning angle still does not address the support issue, we recommend printing the tube horizontally.

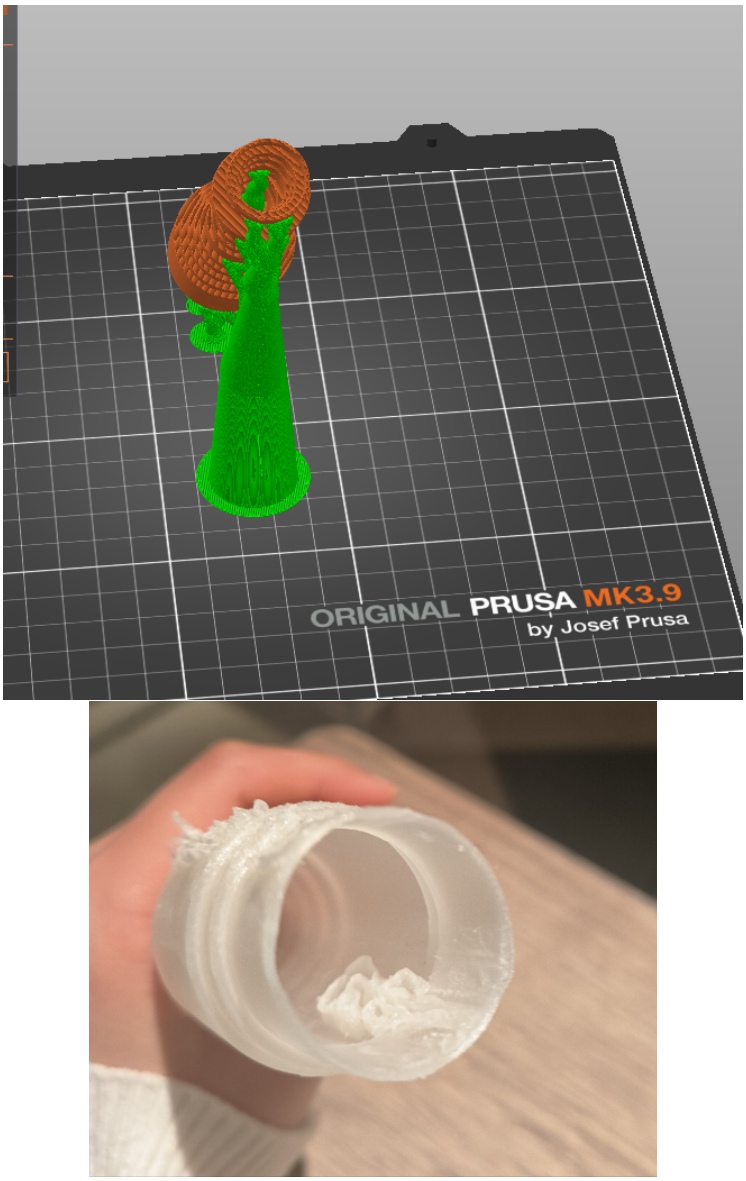

Figure 7: Cleaning organic support

2.3 Filaments

We have tried using PLA, E-PLA, PLA-UV, and PETG as filaments.
For differences between PLA and PETG, please refer to this link(https://www.xometry.com/resources/3d-printing/petg-vs-pla-3d-printing/).
PLA is more suitable for general purposes and easy to use for beginners. E-PLA

is an enhanced version with better layer adhesion and higher strength. The notable feature of PLA-UV is that it changes color under ultraviolet light. It is worth noting that some PLA filaments are more decorative and may have poor stability, such as silk filament and glitter filament.
During the printing process, we frequently encountered stringing issues. This can be caused by various factors. Adjusting retraction settings or using a filament dryer to reduce filament moisture, which is one of the main causes of stringing, can help address this issue.

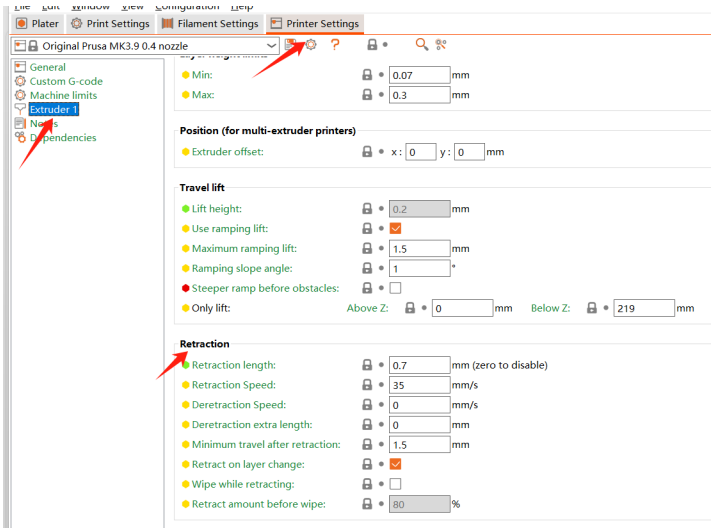

Figure 8: Retraction settings

Figure 9: Filament dryer

3 Detachable Tubes

3.1 Printing Orientation

Considering the need to print connectors (which require high precision in 3D printing), we suggest printing the block upright (as shown in the Figure 10). This allows for the addition of organic supports on the connectors, which can help the filament cool and form better in the connectors. Otherwise, it would cause the filament to be extruded into the air without correctly layering.(Figure 11)

Figure 10: Cubes with organic support

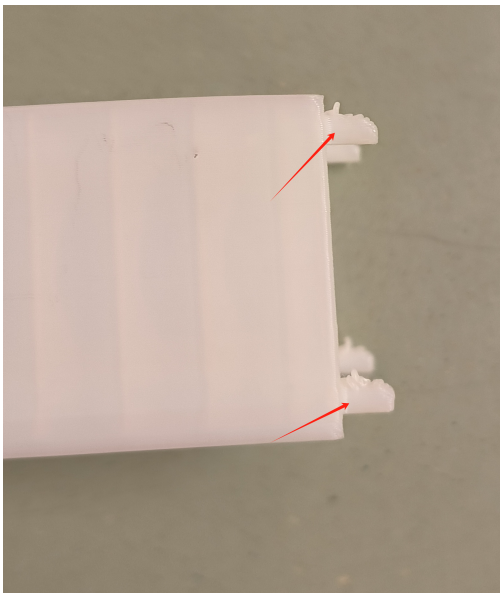

Figure 11: Layering failure

If printed in a vertical orientation, the connectors are relatively fragile. When the force applied to the connectors aligns with the direction of the printed layers, the connectors can easily break.(Figure 12)

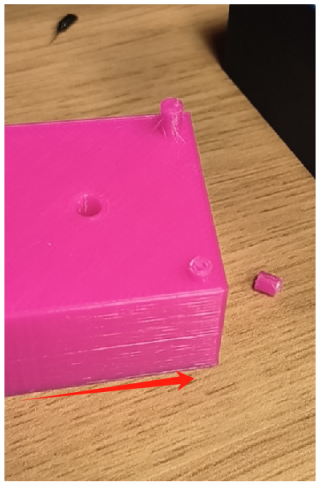

Figure 12: Broken knobs

3.2 Alternative Detachable Tubes

Due to the high precision requirements for printing connectors, issues can easily arise. If the specific parameters of the tube are known, Fusion 360 can also be used to model and design detachable tubes with thread.
Using [u] with four sections as an example, the specific parameters are as follows:
First section: Diameter 3.57mm, Length 20mm
Second section: Diameter 25.23mm, Length 60mm
Third section: Diameter 11.28mm, Length 60mm
Fourth section: Diameter 15.96mm, Length 20mm

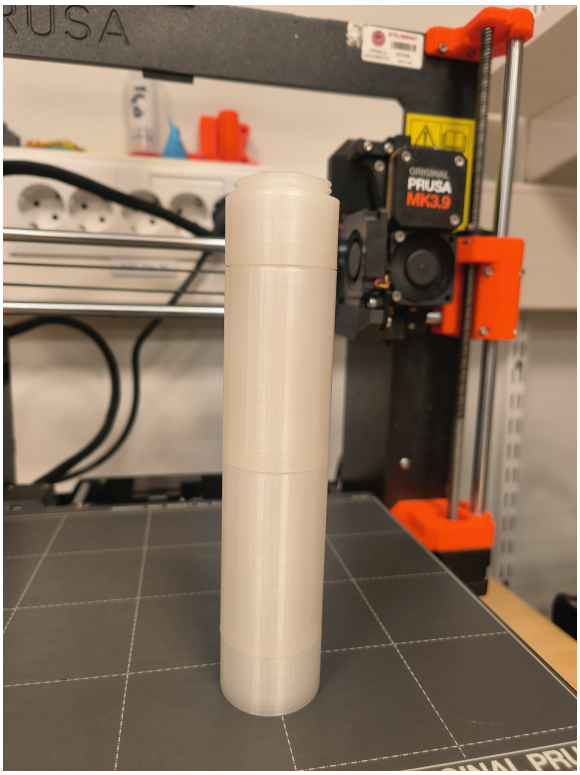

Figure 13: Detachable tube[u] with thread

Step 1: First, select "SURFACE" then click "Create Sketch".

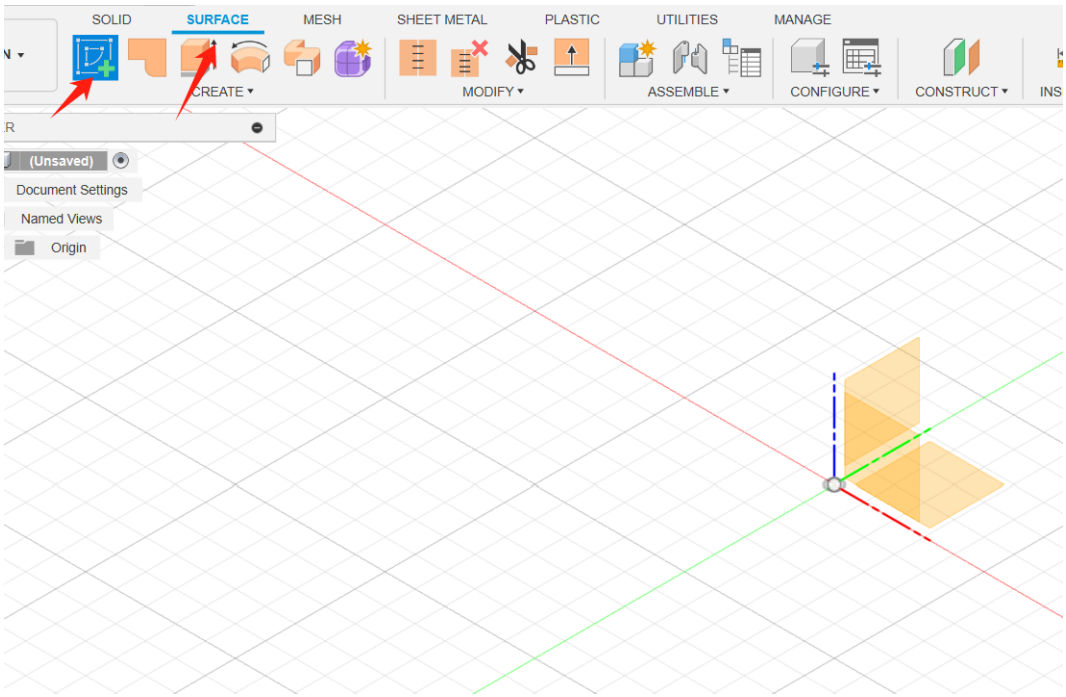

Figure 14: Create sketch

Step 2: Create circles on the sketch.
It is recommended to first determine the "place center point" to avoid any misalignment when creating concentric circles.

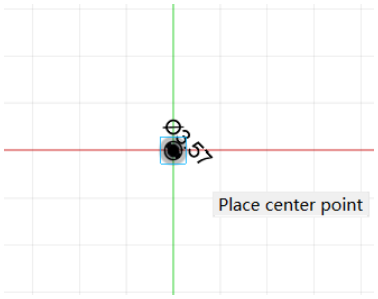

Figure 15: Place center point

The second and third circles are the outer wall of the tube, with diameters of 30mm and 35mm respectively (the outer wall size can be adjusted based on the largest tube area).

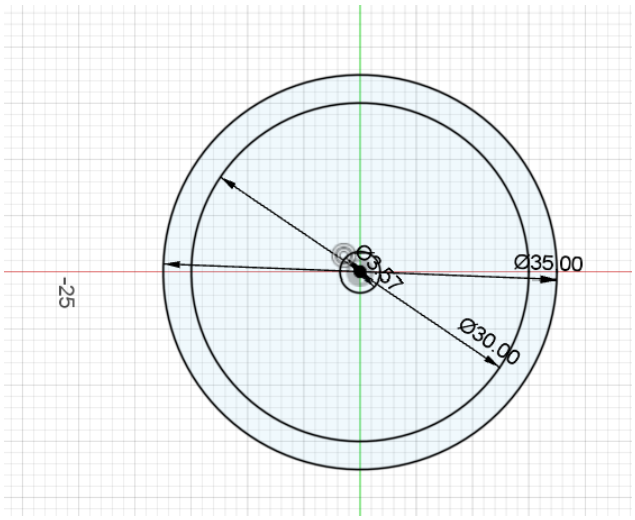

Figure 16: Three circles

Step 3: Extrude the plane to form a solid.
First, click on the circle to be extruded, select "SOLID" then click "Extrude" and enter the desired distance to extrude along the Z-axis (20mm).

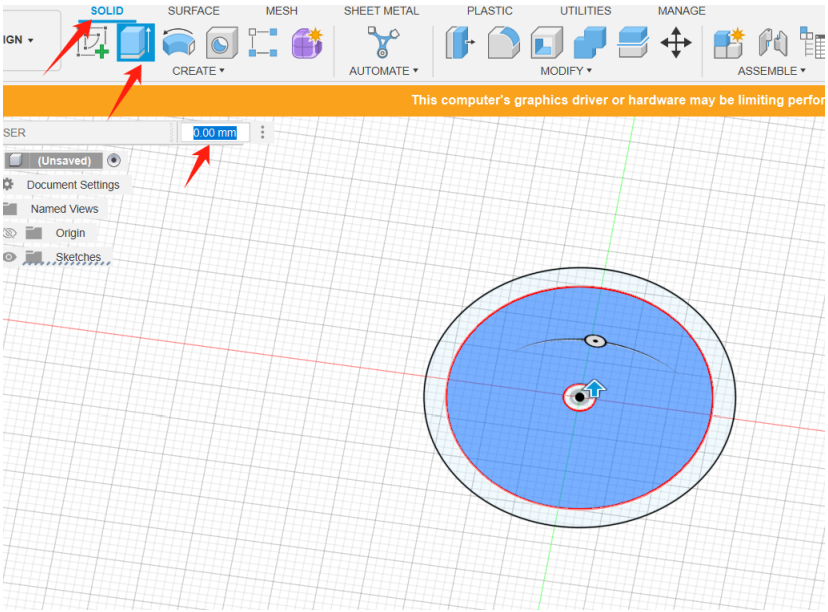

Figure 17: Extrude

Step 4: Move the tube.
Due to the need to space 5mm for adding threads, this part of the solid tube needs to be moved 5mm along the Z-axis.
Select "Move/Copy" then in the popup window, choose "Move Object" and select "Bodies". Next, click on the cylinder and choose "Move Type".

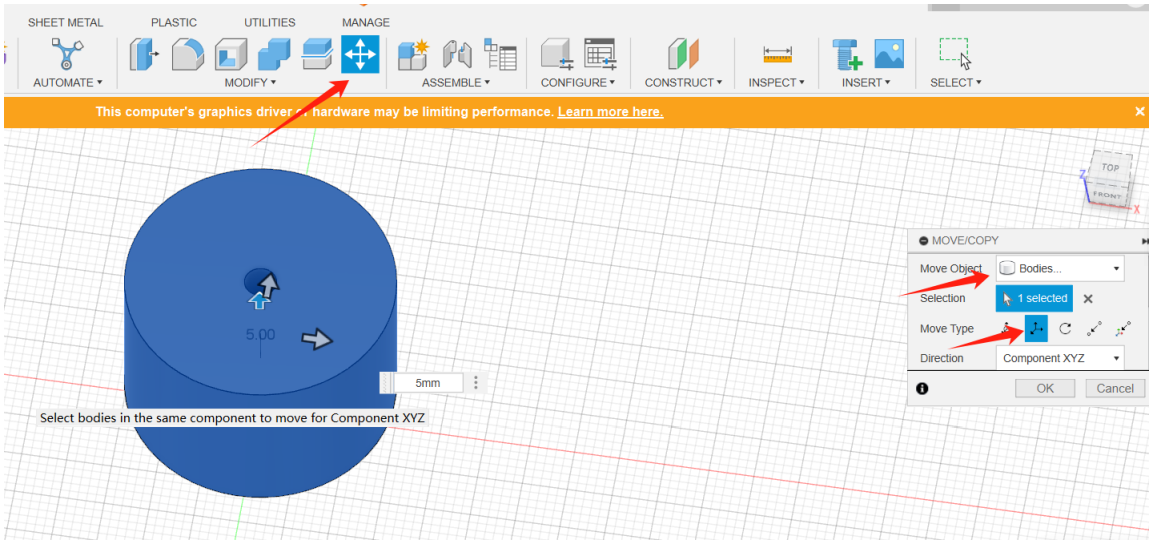

Figure 18: Move the tube

Step 5: Extrude the outer wall.
At this point, the sketch for the outer wall of the cylinder will be hidden. Click on "Sketches" to make the sketch visible again. Repeat the "extrude" step3 to extrude the outer wall portion by 20mm.

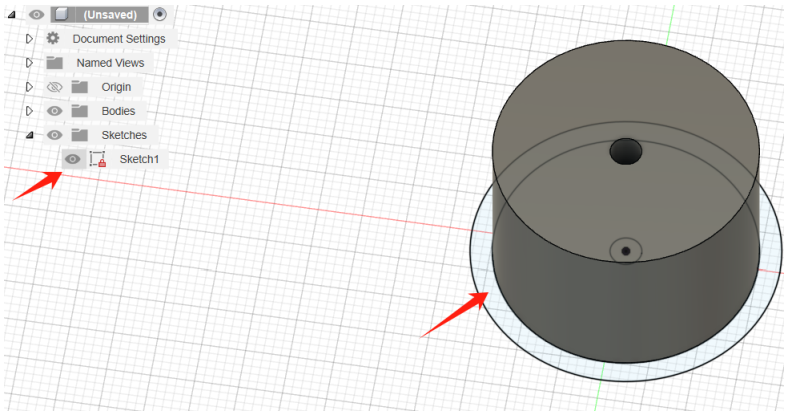

Figure 19: Show the sketch

Step 6: Add threads.
Click on the part where the thread needs to be added and select "Thread". In the popup window, make sure to check "Modeled" and "Remember Size". Since we only have 5mm reserved for the threads, coarse threads would make the connection insecure, while fine threads would complicate the printing process. Thus, we opted for moderate parameters to strike a balance.

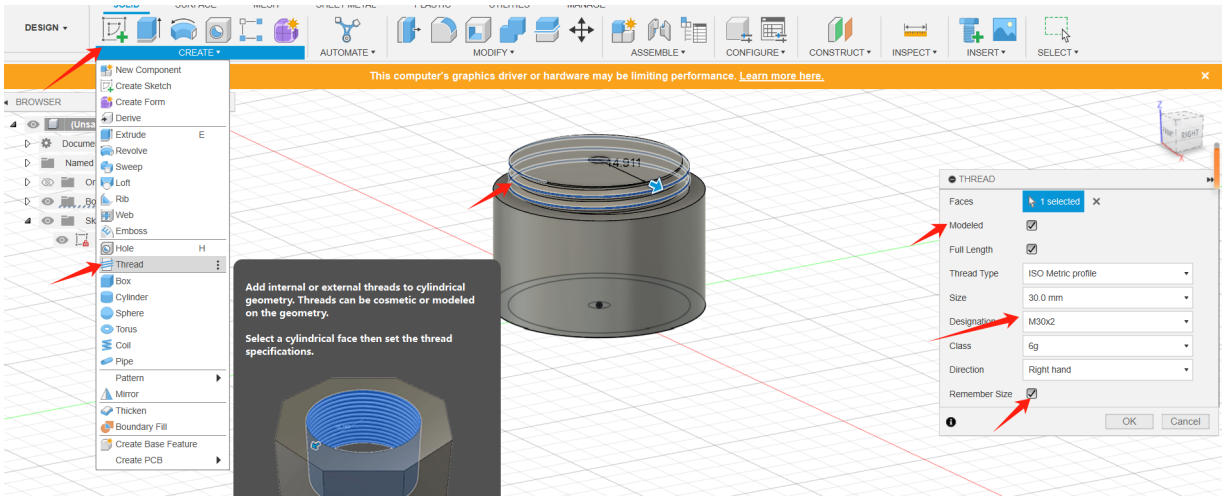

Figure 20: Add threads$_{t}op$

Hide the sketch, click on the bottom part of the cylinder where the thread needs to be added, and then repeat the previous step.

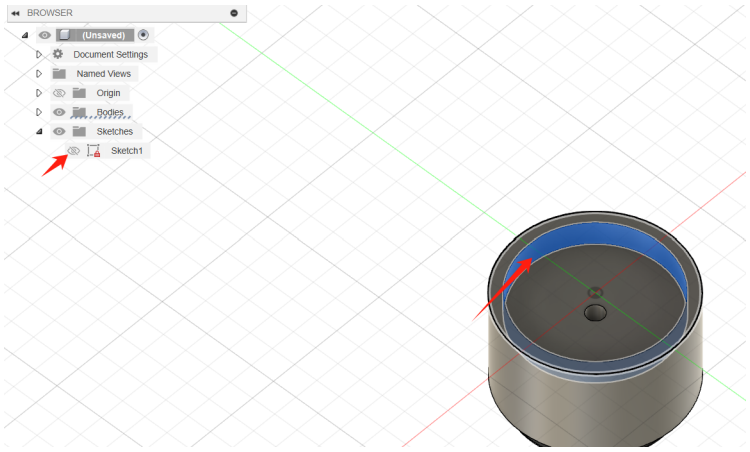

Figure 21: Add threads$_b$*ottom*

Since the glottis needs to connect with the duck lure to produce sound, we keep the recessed area at the bottom of the glottis (the fourth section) for easier connection. Previously, our design was as shown in Figure 22, but this made it difficult to connect with the duck lure.

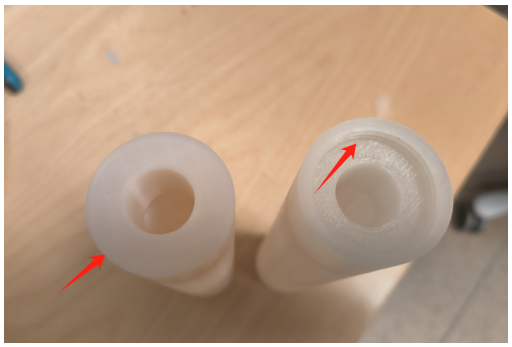

Figure 22: Previous design

Step 7: Export as .stl file.
You can import this .stl file into PrusaSlicer software and adjust the printing settings and export as G-code to print the tube.

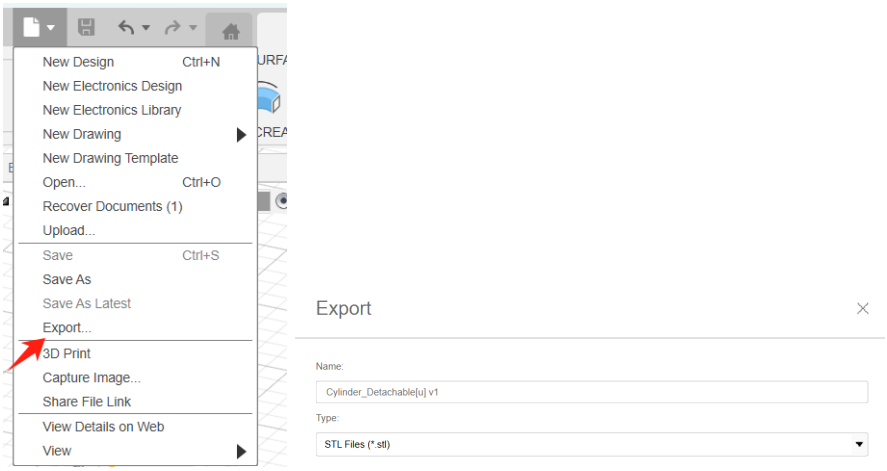

Figure 23: Export as .stl file

Since the cylinder itself is quite stable, we tried printing the tube without adding organic supports and only set "Support on the build plate only". The printing results were good. We manually removed the bottom support using pliers.

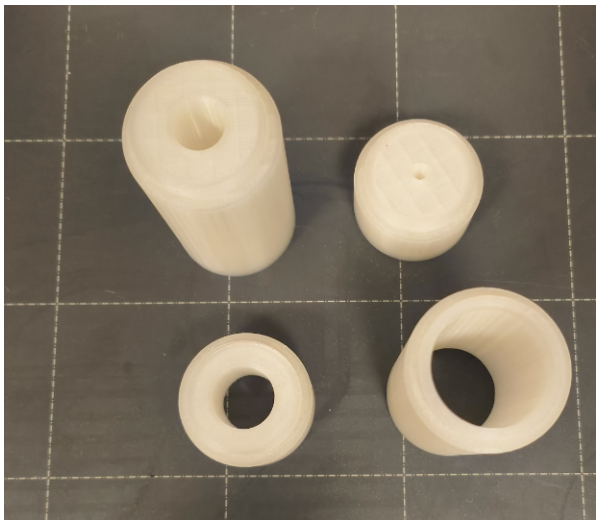

Figure 24: Final result

Figure 25: Continuous Tubes

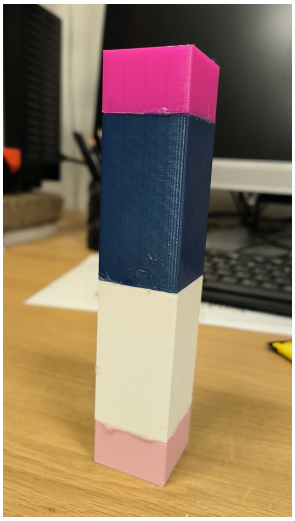

Figure 26: Cube-shaped Detachable Tube

Figure 27: Cube-shaped Detachable Tube

In actual printing, it is very likely that solving one problem may lead to new issues. We recommend making adjustments based on specific print results and trying few more times.

If you find any errors in the manual or have better solutions to the issues mentioned, we warmly welcome you to contact us: rui.tu.6194@student.uu.se. We greatly appreciate your valuable feedback. And we will also update this manual based on the outcomes of future printing experiments.

Finally, we would like to express our gratitude to Uppsala University's EBC Makerspace for their assistance and advice on 3D printing for this project.