We can’t guarantee your model will successfully print as there are many factors which can affect it.
The guideline will help you understand 3D printing in greater detail to help you achieve a successful print.

How do 3D printers work?

3D printing, or additive manufacturing, is a process of making three dimensional solid objects from a digital file.

The 3D printer cannot print directly from any digital model file.
It needs a specific file format that contains toolpath created from the 3D digital model to specify the printer's movement, when to start and stop pumping molten plastic, and at what rate.

This guide will show you **how to prepare your digital model file for file export to 3D print.**

Ultimaker 3 Extended

3D printer models at OML

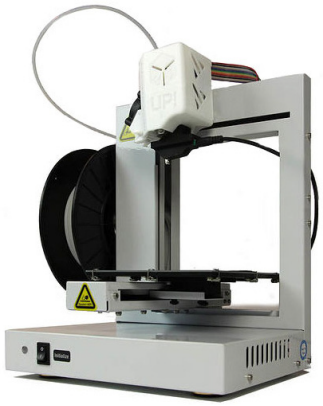
The Ultimaker printers are located in the OML Office Level 3

Typically there are long queues due to long printing times and demand. It is unpredictable when your file will be printed, we recommend you submit the file 3-4 days beforehand.

Ultimaker 3 Extended

Max model dimensions

Width: 215mm
Depth: 215mm
Height: 300mm



UP Plus 2

UP printers can be hired by design tutors for studio use.

UP Plus 2

Max model dimensions

Width: 130mm
Depth: 130mm
Height: 125mm

Overview

To 3D print, a program such as UP! or MakerBot is used to export the toolpath from the digital model.

How Does The Export Work?

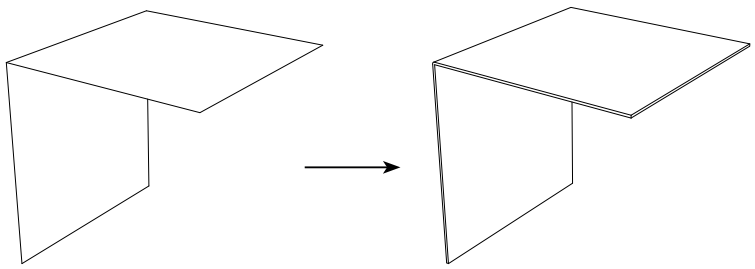
A. The digital 3D model is converted into 2D slices that are read by the machine.

B. The 3D printer heats plastic filament and extrudes it through a nozzle onto a heated surface.

C. The solid object is built layer by layer.

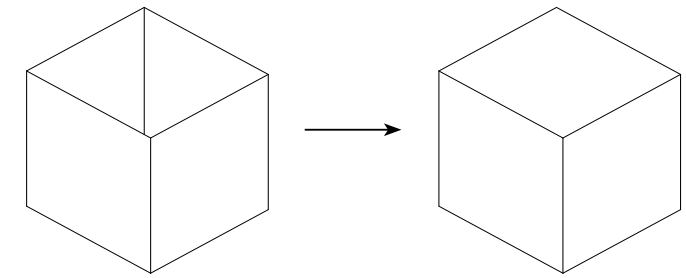
This method is called Fused Deposition Modelling (FDM)
or Fused Filament Fabrication (FFF)

GCode (toolpath)
The toolpath is specified in GCode, a standard language for controlling CNC machine tools.



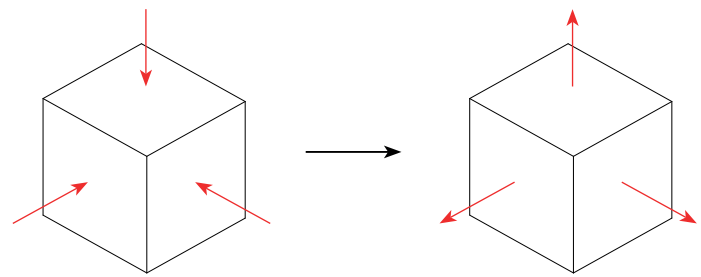
Surfaces **will not** export for 3D printing.

Convert surfaces into **solid** volumes.



Open volumes **will not** export for 3D printing.

Ensure your volumes are fully **enclosed** solids.



Inward-facing surface normals **will not** export for 3D printing.

Ensure your surface normals are facing **outwards.**

Preparing your model for printing

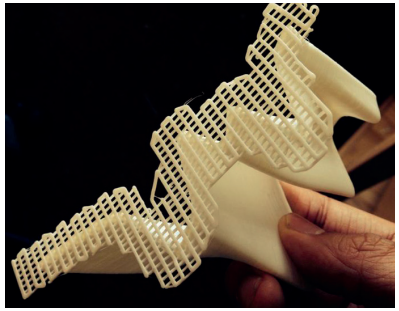
1. Must be a **SOLID Volume**,
   it cannot be planar surfaces. It needs a **thickness.**

2. Save your model in **.STL** format.
   (this is a mesh format - NURB surfaces will be triangulated)

- Make sure your volume has no holes, the volume must be fully **enclosed**.
- Make sure surface normals are facing **outwards** and not inwards.
- Model dimensions must fit in the printing bed constraints (width, depth and height).

Filament Thickness
The thinnest width the Makerbot Replicator 2X will print is 0.7mm.

Overlaps
Printers are able to print overlapping geometry, however overlaps can cause errors and/or siginificantly increase time taken to export the toolpath.
It is recommended to produce a clean, non-overlapping model.

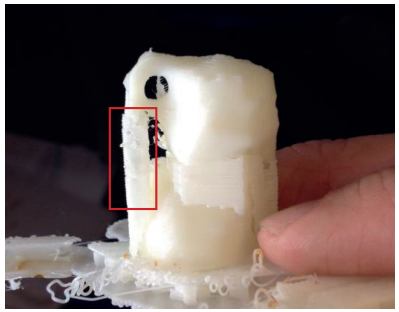


3D Print General Information

A 3D Print will be printed with:

Rafts
A raft is a flat base that is printed.
It is temporary, helps stick the 3D print securely to the build plate.

- Support structures might not adhere well to the build plate without a raft.

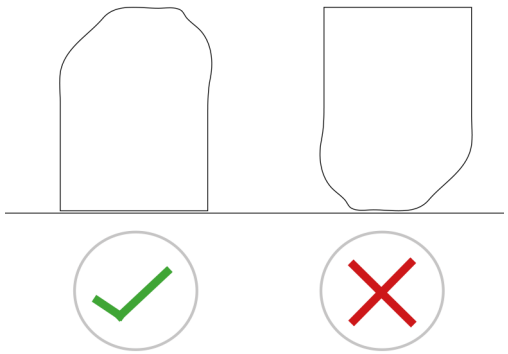


Supports
Supports allow printing of overhanging parts.
3D printers cannot print into thin air, supports provide a base for overhanging parts of a model.

- You can remove supports by tearing away with pliers or with your fingers.

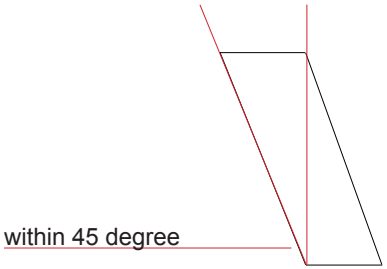
- Supports can leave surface imperfections that require finishing of the object.
  Eg. sanding down, or dissolving with acetone.

- Supports can also use up a significant amount of plastic.
- Supports can be reduced if your object has a flat side to rest on.
- Orient your object to minimize overhangs and bridges.



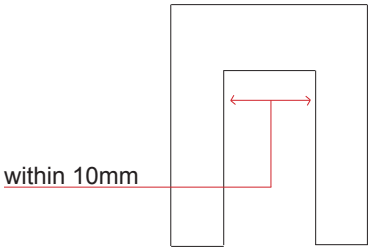
To get the print done **faster,**
Place the object so the bottom is as flat as possible.

Extra Tips



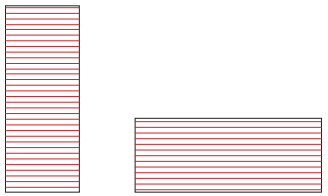
Overhangs
As the printer prints your object, each layer of plastic rests on the one below.
When an object has straight sides, the new layer will be fully supported by the previous layer.

- To avoid printing supports, avoid creating overhangs that form an angle greater than 45 degrees from the vertical.
- Make sure at least half of each layer's outer perimeter is supported.



Bridges
A thread of extruded plastic that crosses from one supported area over an unsupported area is called a bridge. Because the thread is supported at both ends, the unsupported middle does not cause problems.
If the unsupported section is too long, it may sag in the middle.

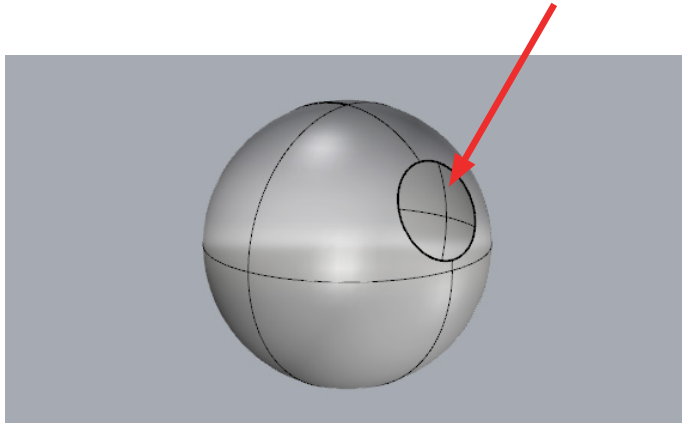
- 3D printers should handle bridges of 10mm well
- Sagging occurs on bridges of 20mm



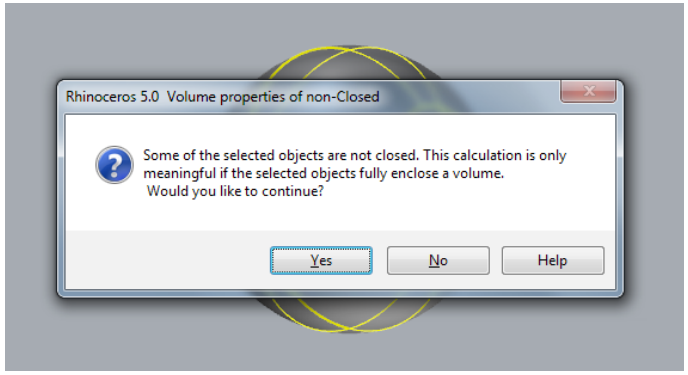
Maximizing Object Strength
Another thing to consider is the 'grain' of the printed object.
Keep this in mind when designing functional objects:

- A thin cylinder printed upright will be composed of circles placed on top of one another. If bent in half, it has many natural breaking points and will snap easily.
- If it is printed on its side, the layers will run up along the cylinder. Every layer will have to bend in order for the cylinder to break.

How to check for enclosed volumes in Rhino



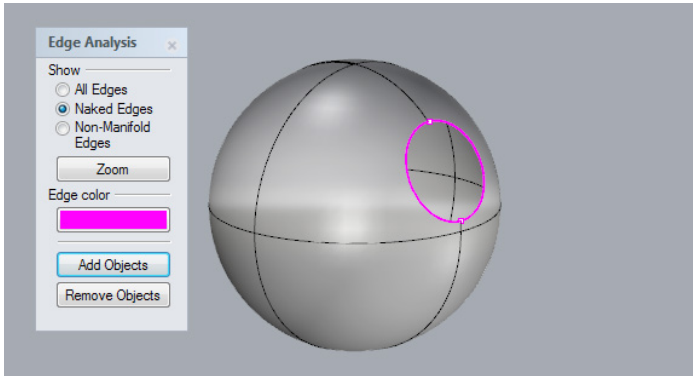
Example of a unenclosed volume.
Unenclosed volumes are unable to be exported for 3D printing.



To check if the object is enclosed
Select the object and go to:

[Analyze] > [Mass Properties] > [Volume]
(or type in the command bar: Volume)

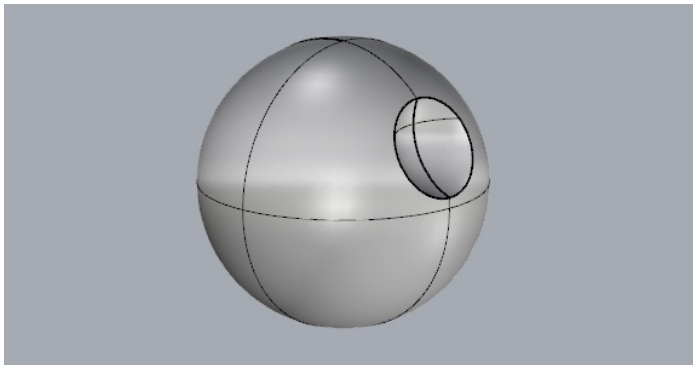
IF a pop-up window appears, your model is not enclosed.



To easily select the unenclosed edges (naked edges)
Select the object:

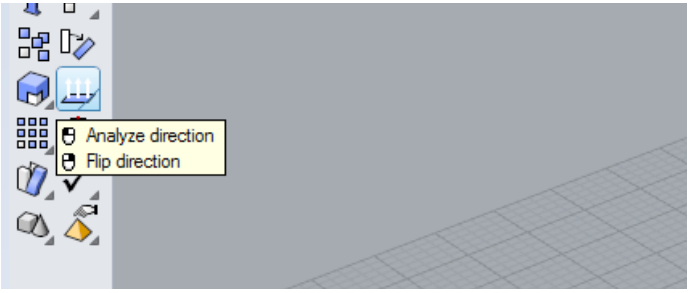
[Analyze] > [Edge Tools] > [Show Edges]

Check show naked edges to show the unenclosed edge



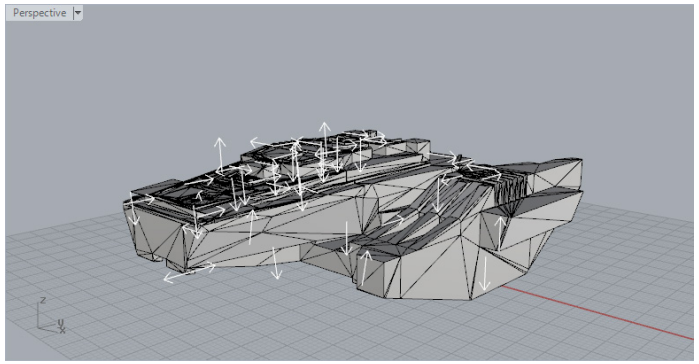
Close all naked edges before 3D printing.

Make sure to use the command join to ensure the object is one solid form.
You will then get an enclosed volume that is printable.

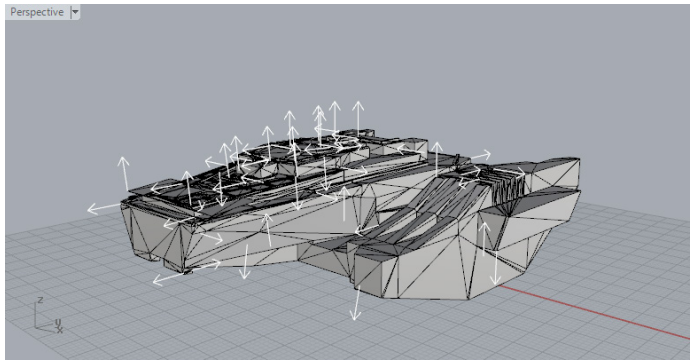


Check for normals in Rhino

Make sure the normals are facing the correct direction.
Use Analyze directions/Direction display, command “Dir”

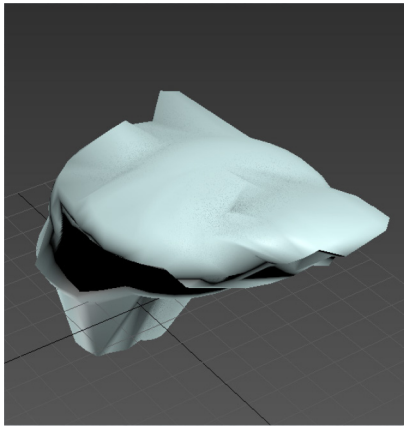


If **any** surfaces are facing inward it will **not be printable**.

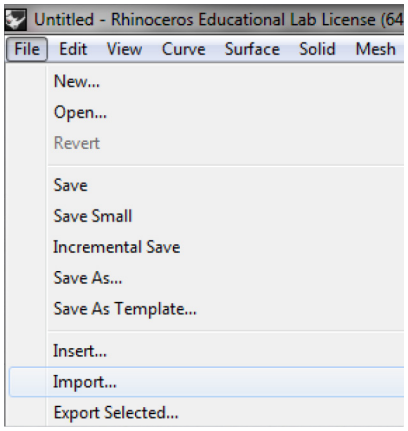


Use command “Flip” to change surfaces to facing **outwards**

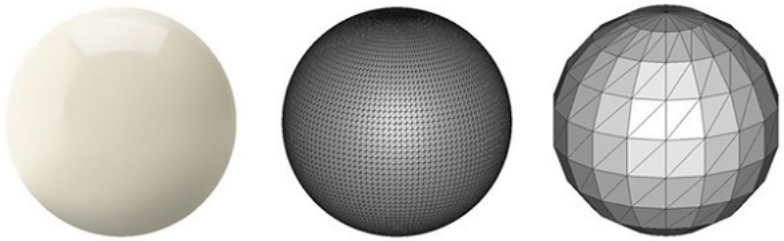
Files created from other programs can be imported into Rhino for analysis.



Example model built in 3ds Max



Import 3D model for analysis
[File] > [Import]



STL (.stl)
STL is a widely used type of 3D model file.

- It consists of surfaces of triangles.
- Each triangle has an inner and an outer side.
- The outer side is called the normal.
- In a well-formed STL, all the normals face outwards and the surface is contiunous with no holes.
- When a model meets these standards, it is referred to as manifold.
- STLs with normals that face inwards (inverted normals) may be printable, but a manifold model is considered a prerequisite for 3D printing.
- STLs are compatible with many 3D modeling programs and have become the standard file type for 3D printable models.
- SolidWorks®, Rhinoceros®, and most Autodesk® programs will export STL files, and there are free plugins available that will allow you to export STLs from SketchUp®.

```
M103 (disable RPM)
M73 P0 (enable build progress)
G21 (set units to mm)
G90 (set positioning to absolute)
M109 S110 T0 (set HBP temperature)
M104 S220 T0 (set extruder temperature) (temp updated by print0Matic)
(**** begin homing ****)
G162 X Y F2500 (home XY axes maximum)
G161 Z F1100 (home Z axis minimum)
G92 Z-5 (set Z to -5)
G1 Z0.0 (move Z to "0")
G161 Z F100 (home Z axis minimum)
M132 X Y Z A B (Recall stored home offsets for XYZAB axis)
(**** end homing ****)
G1 X-110.5 Y-74 Z150 F3300.0 (move to waiting position)
G130 X20 Y20 Z20 A20 B20 (Lower stepper Vrefs while heating)
M6 T0 (wait for toolhead, and HBP to reach temperature)
G130 X127 Y127 Z40 A127 B127 (Set Stepper motor Vref to defaults)
M108 R3.0 T0
G0 X-110.5 Y-74 (Position Nozzle)
G0 Z0.6      (Position Height)
M108 R5.0    (Set Extruder Speed)
M101         (Start Extruder)
G4 P2000     (Create Anchor)
```

GCode
GCode is a computer language for controlling CNC machines, including 3D printers.

- When software slices your 3D model into a set of instructions, they are written in GCode.
- The instructions command the temperature of the extruders, where to move, when to extrude plastic, control of the build platform and peripheral components.
- 3D printing software converts human-readable GCode to the more compact, computer-readable X3G.
- You can’t edit X3G files, but you can edit GCode eg. change extrusion temperatre and insert extra commands.