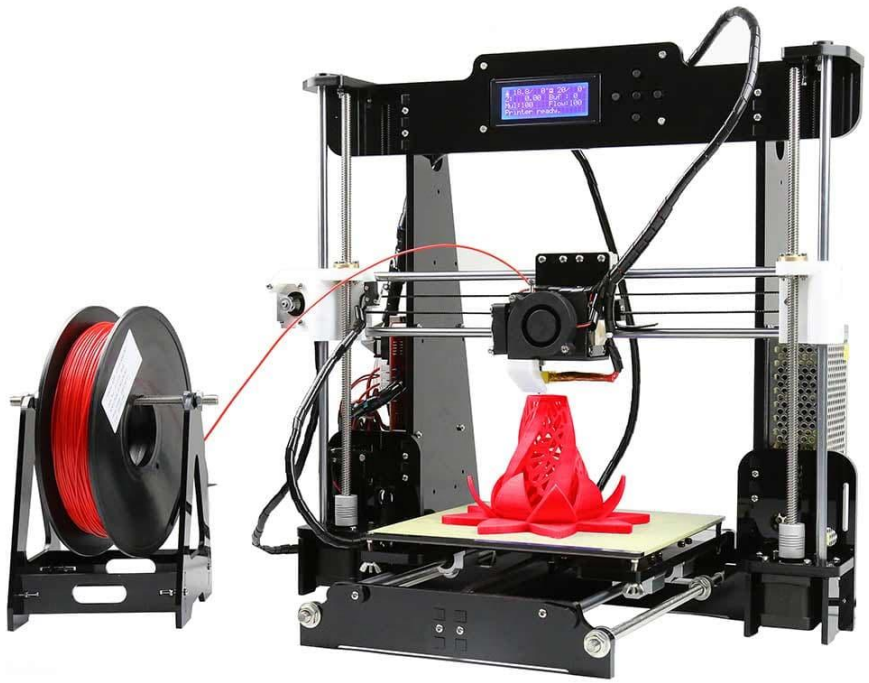
3D-Printing Basics



Contents

I. Online 3D Model Databases
II. Designing your own Models
III. 3D File Types
IV. Cura &Octopi– Preparing your model for Printing
V. Introduction to Printing materials
VI. Re-Calibrating your Printer

Finding projects and files online

- Thingiverse (https://www.thingiverse.com/)
  - Toys, Replacement parts, Deco, fan articles, table top figures…
  - Single models
  - Larger Projects with instructions
  - Usually STL files, sometimes also editable (program specific files)
- The Models Resource (https://www.models-resource.com/)
  - Video Game models
  - Copy Right Questionable

Finding projects and files online

- Happy 3D (https://www.happy3d.fr/en/)
  - by French Electronic company “Boulanger” (also models for other brands)
  - Replacement parts only
  - Original CAD Data
  - Community uploads checked for being printable
- MyMiniaFactory (https://www.myminifactory.com/)
  - Community based
  - Curated
  - Similar to Thingiverse

Designing your own model

- Why?
  - Can´t find it online
  - Custom parts needed for own Project
- How long?
  - Depends on
    - Complexity
    - Your experience
  - 10 min- multiple hours
  - Plan redoing your projects

3D Design Programs

Technical Design

Artistic Design

Code based

Sketching and extruding

And many more….

OpenSCAD

- Open source
- Works on all OS
- Requires some programming skills
  - Cheat Sheet: http://www.openscad.org/cheatsheet/7

Sculptris

- Used for making models which are hard to sketch using geometrical forms
- Principle: starting with a lump of clay → moulding it, pulling it, etc…
  - Requires some artistic skills and practice with the program
- Digital Art and Model Creation
- Few personal experience yet
- Download: http://pixologic.com/sculptris/

Design Spark Mechanical

- Commercial but free for private use
- Windows Only (No Mac / Linux support)
- Requires Registration
  - Feel free to supply it with your spam email
  - and fake infos (e.g. https://www.telefonpaul.de/)

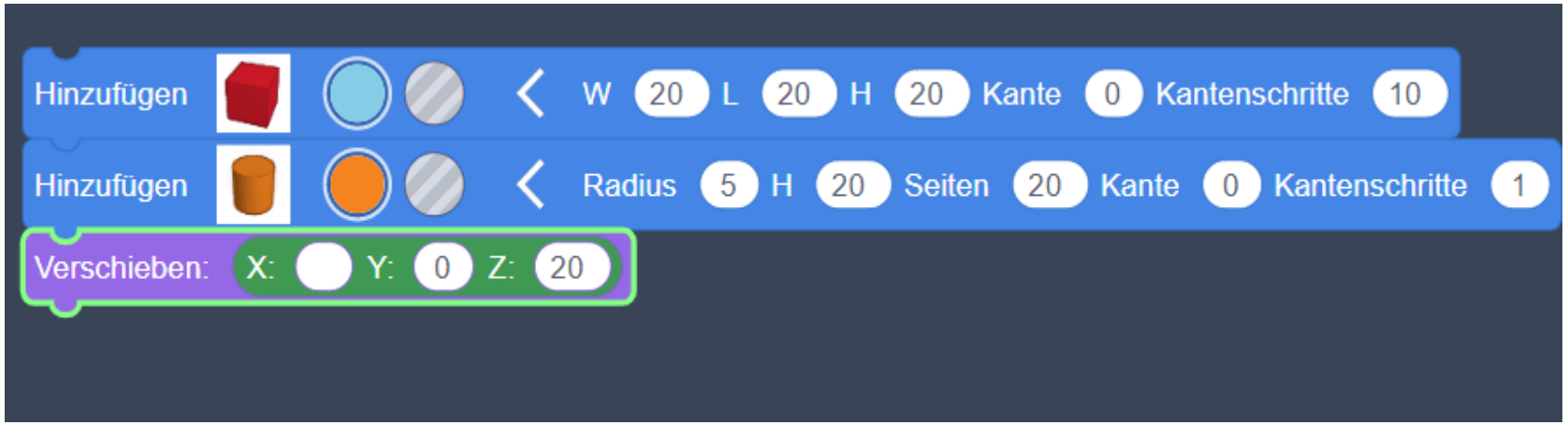
- Download: (https://www.rs-online.com/designspark/mechanical-software)
- Very Similar to Autodesk Fusion 360
- Principle:
  - Sketch a 2D Plane
  - pull (=extrude) it in z-Dimesion
  - Cut unwanted pieces out

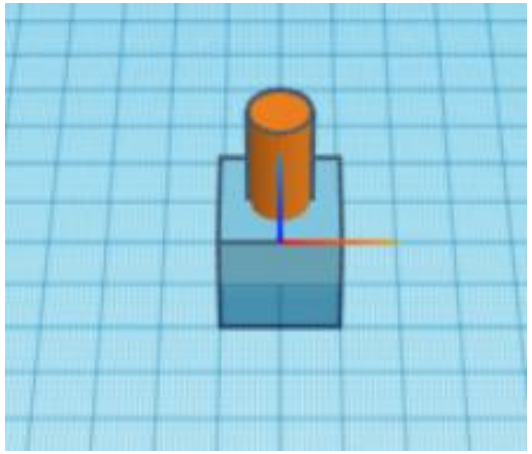
Autodesk Fusion 360

- Professional Program
- Support for Mac and Windows (No Linux support)
- Expensive License
  - 3 year free student license
  - Here: https://www.autodesk.de/products/fusion-360/students-teachers-educators#
- Same Principle as DS Mechanical
- Advantages:
  - Improved interface
  - Contains standardized models (e.g. threaded holes according to ISO standard)
  - Includes G-Code conversion function

Tinkercad

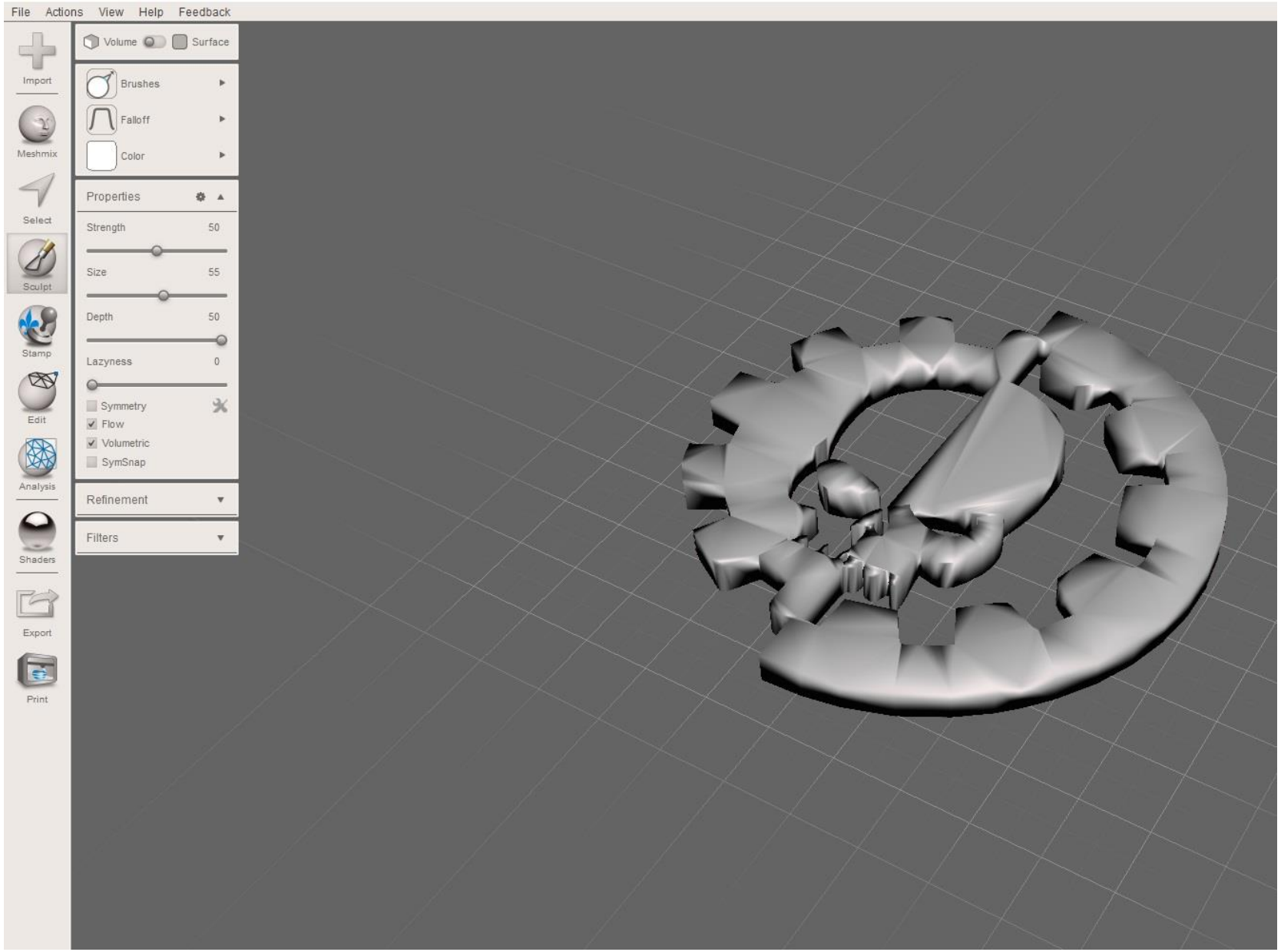
- Free Online Software
- Allrounder with multiple approaches
  - Dragging & Dropping Froms
  - Codeblock based
    - Like OpenSCAD but prepared Codeblocks as jigsaw pieces





Meshmixer

- Free Online Software
- Suited for sculpting and (to a slightly lesser extent) technical designs
- Easy to learn
- Wide array of features



3D File Types

- **Program specific types**
  - OpenSCAD_File
  - RSDOC
  - …

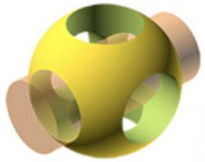
  →only usable with the design program/ programs by the same developer

- **STL**
  - Surface of the model
  - Divided into triangles → no perfect circles possible
  - Used as an exchange format

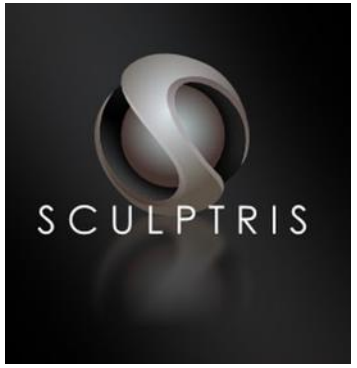
3D- File Types

- **STEP (Standard for the Exchange of Product Data)**
  - Read only
  - Common exchange format
- **G-Code**
  - Developed 1950 at the MIT (Massachusetts Institute of Technology)
  - Encodes Instructions for computer controlled tools (e.g. x,y,z-movement)

  → File type used by the 3D Printer



OpenSCAD

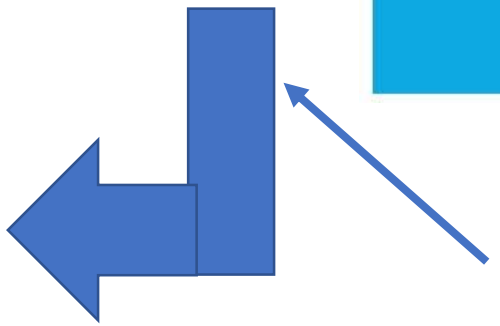


AUTODESK®
FUSION 360™

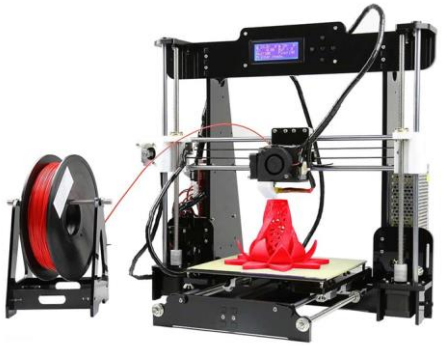
STL / OBJ

G-Code

Instructions

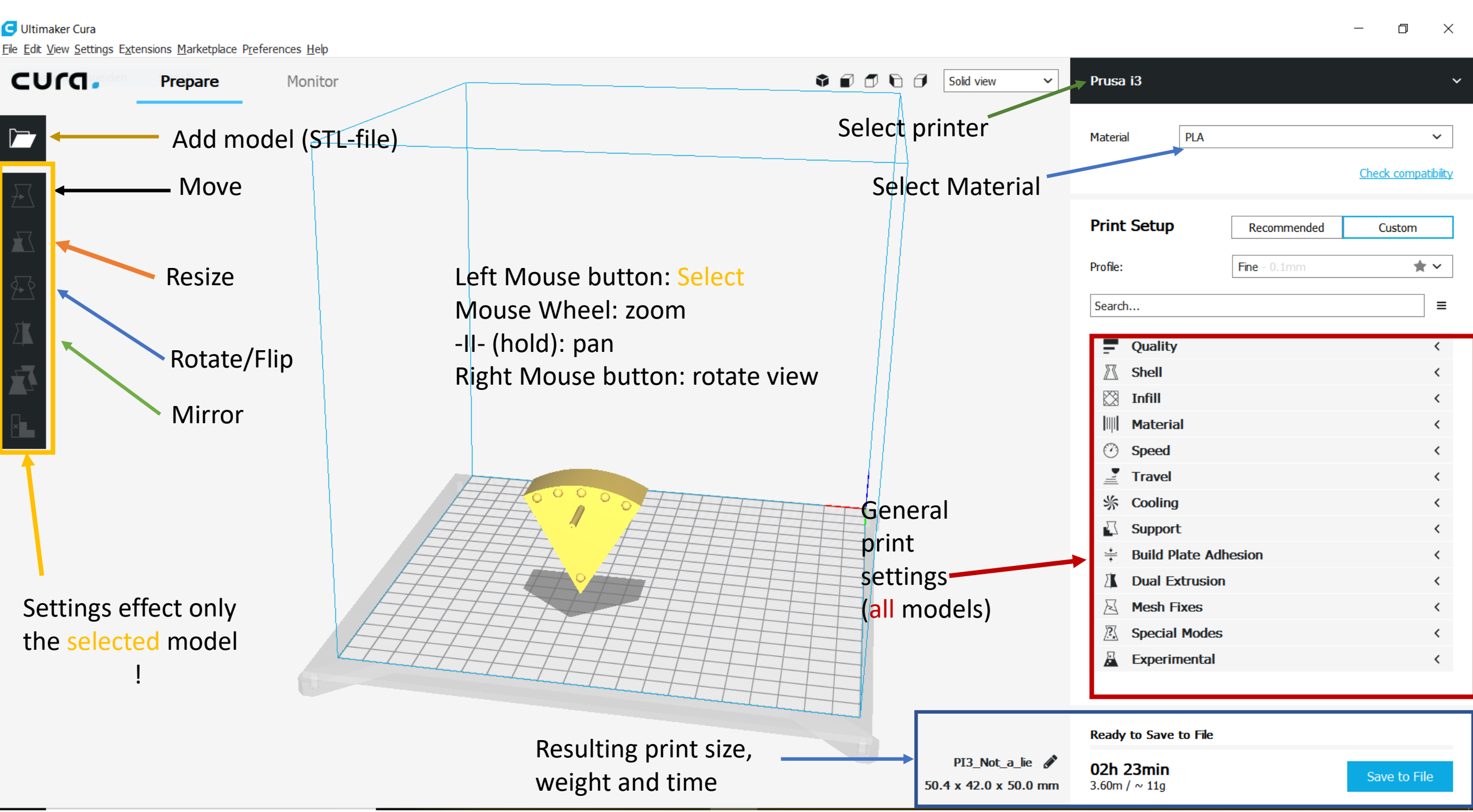


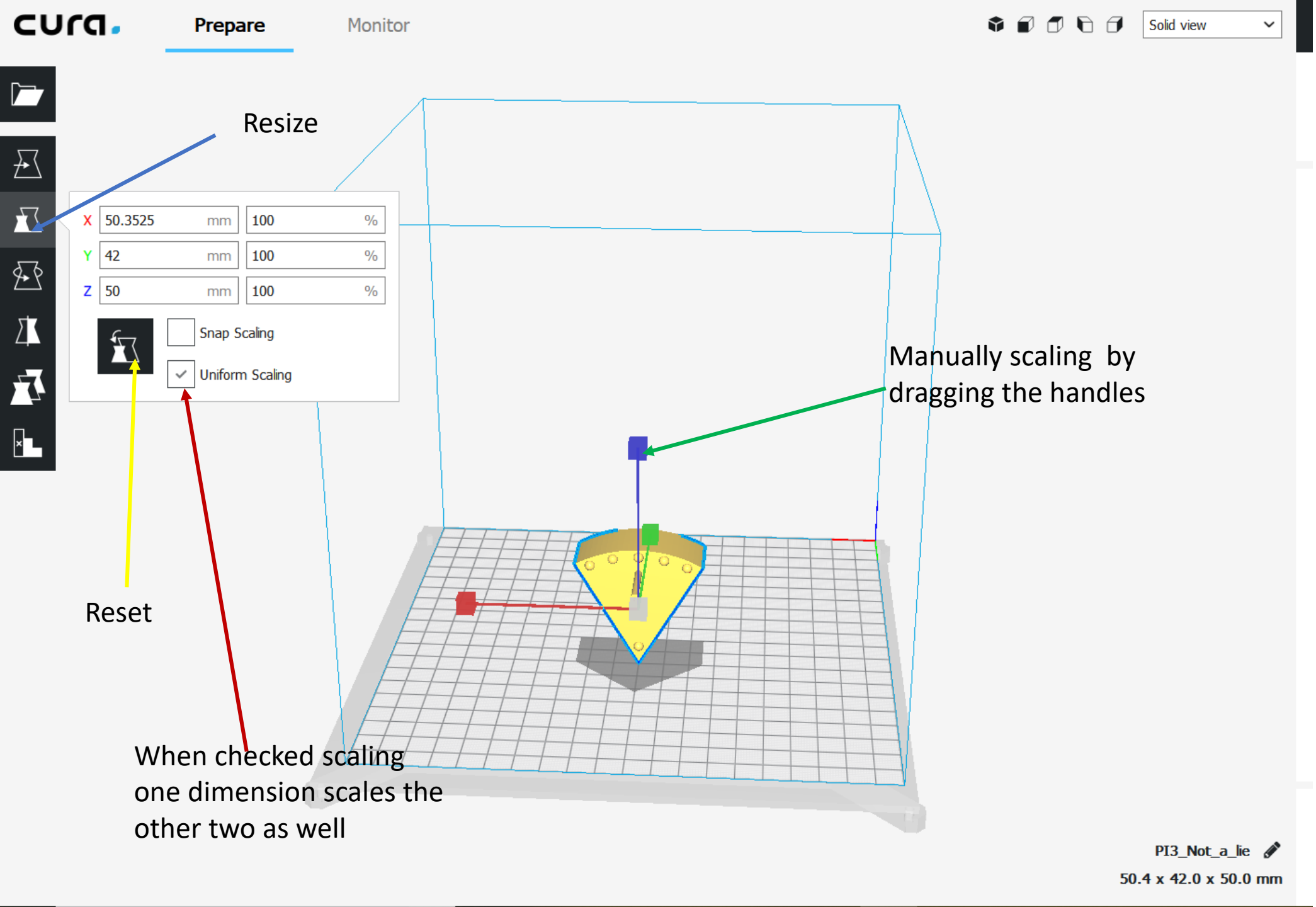
Exchanging Designs via STL
between Programs
Possible, but Tricky !

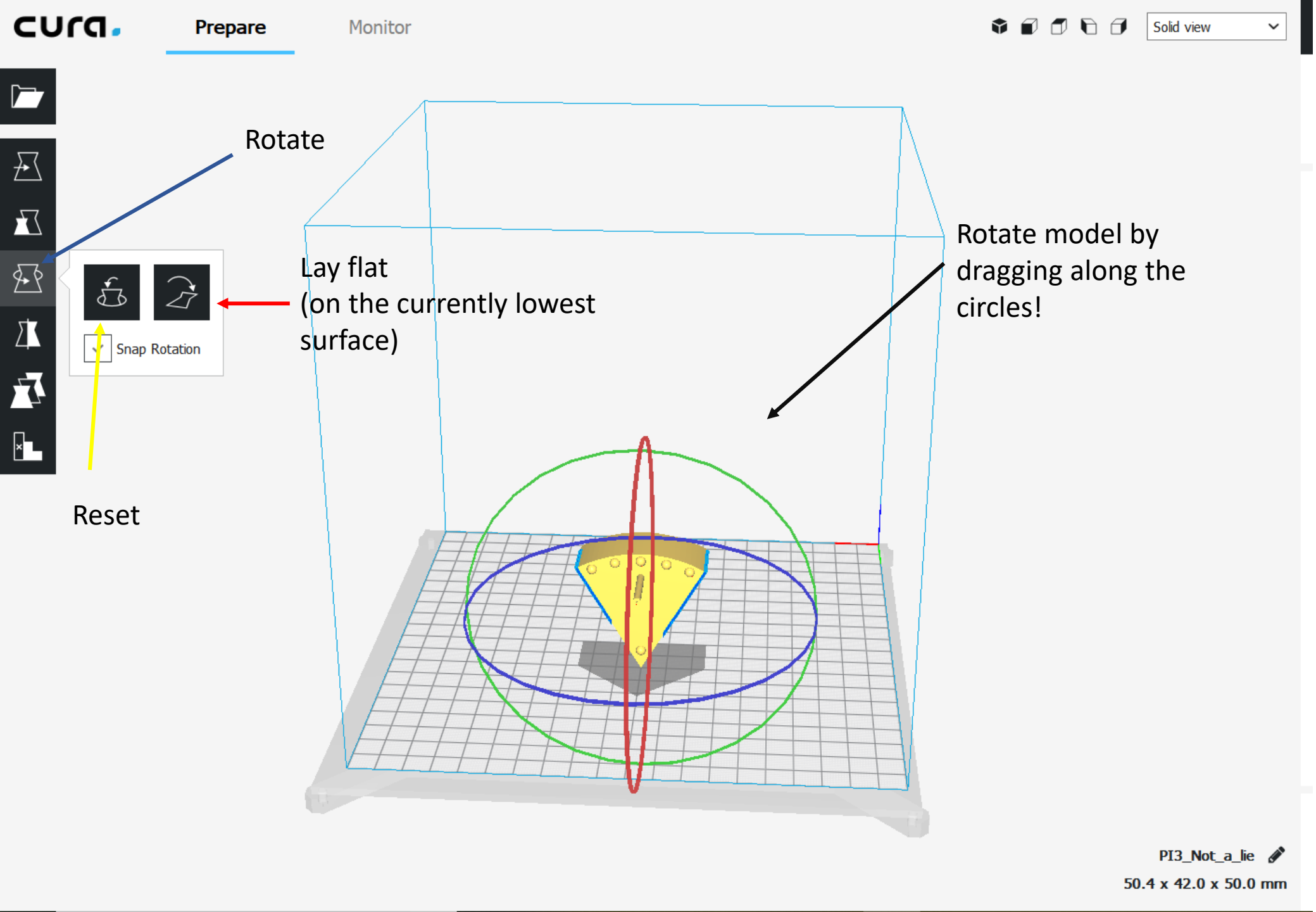


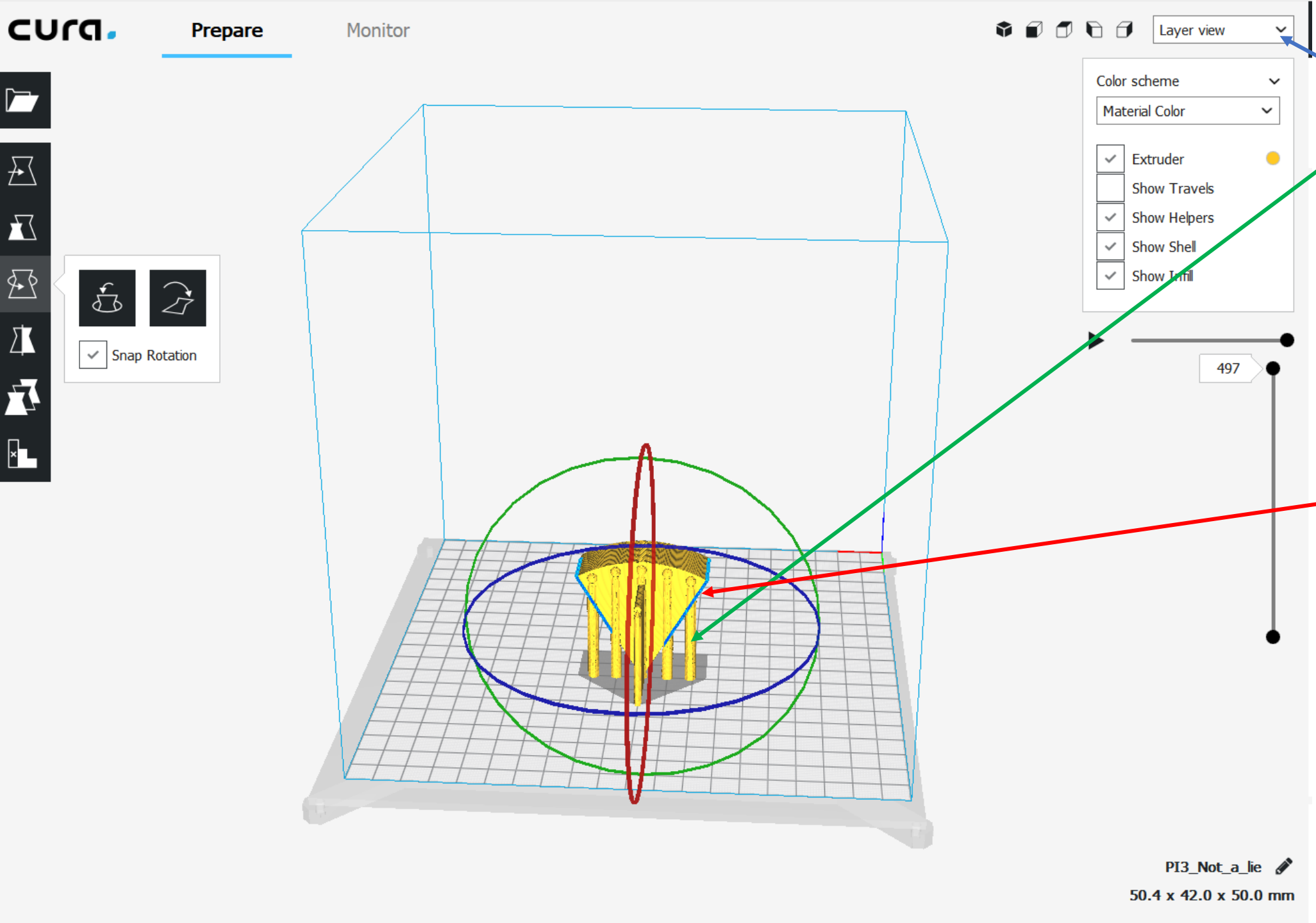
Cura

- Converts STL Files into G-Code (= instructions for the Printer)
- Allows to choose settings for the printing process
  - Scaling, rotating
  - Extruder and printing bed temperature
  - Infill
  - Adhesion Plates
  - Support Structures
  - …


Ultimaker Cura
File Edit View Settings Extensions Marketplace Preferences Help
Prepare
Monitor
Solid view
Prusa i3
Add model (STL-file)
Move
Resize
Rotate/Flip
Mirror
Select printer
Select Material
Material
PLA
Check compatibility
Print Setup
Recommended
Custom
Profile:
Fine - 0.1mm
Search...
Left Mouse button: Select
Mouse Wheel: zoom
-II- (hold): pan
Right Mouse button: rotate view
Quality
Shell
Infill
Material
Speed
Travel
Cooling
Support
Build Plate Adhesion
Dual Extrusion
Mesh Fixes
Special Modes
Experimental
General print settings (all models)
Settings effect only the selected model !
Resulting print size, weight and time
PI3_Not_a_lie
50.4 x 42.0 x 50.0 mm
Ready to Save to File
02h 23min
3.60m / ~ 11g
Save to File


cura
Prepare
Monitor
Solid view
Resize
X 50.3525 mm 100 %
Y 42 mm 100 %
Z 50 mm 100 %
Snap Scaling
Uniform Scaling
Manually scaling by dragging the handles
Reset
When checked scaling one dimension scales the other two as well
PI3_Not_a_lie
50.4 x 42.0 x 50.0 mm


cura
Prepare
Monitor
Solid view
Rotate
Lay flat
(on the currently lowest
surface)
Snap Rotation
Reset
Rotate model by
dragging along the
circles!
PI3_Not_a_lie
50.4 x 42.0 x 50.0 mm

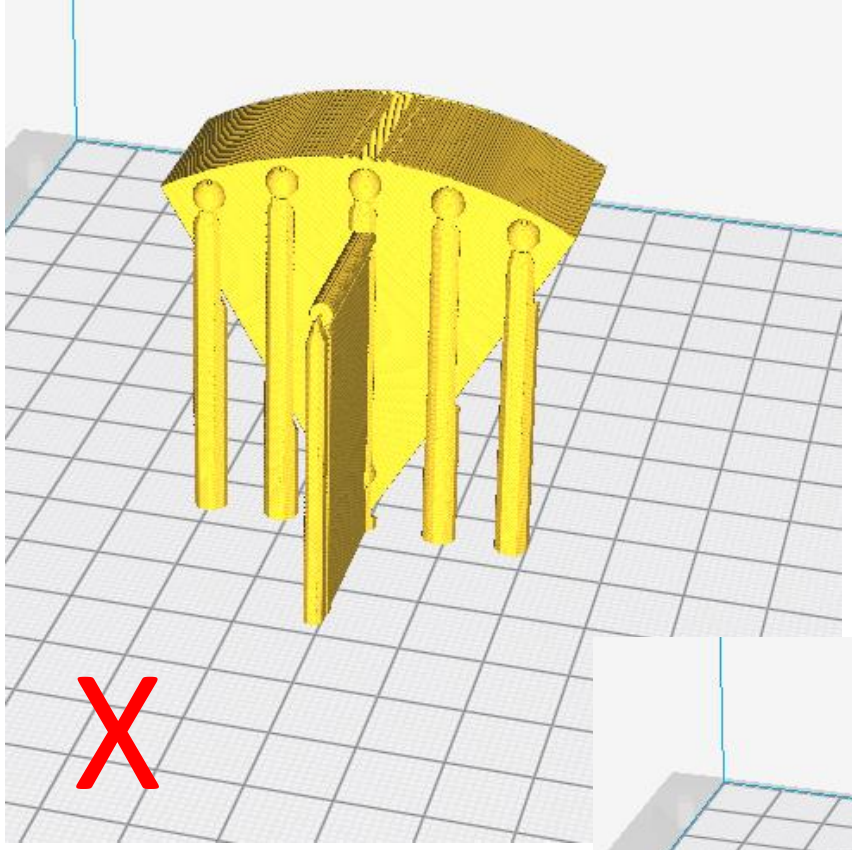


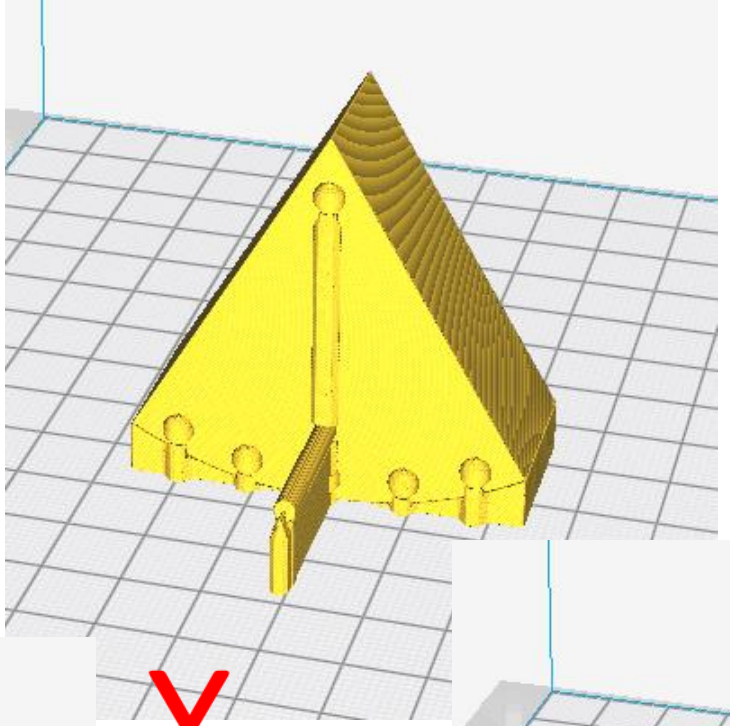
Select “layer view” to see Support structures

Overhanging structures >45° Need Supports

Some overhangs <45°
Will be printed but are still difficult to print!

Rotate accordingly (And use the lay flat function)


X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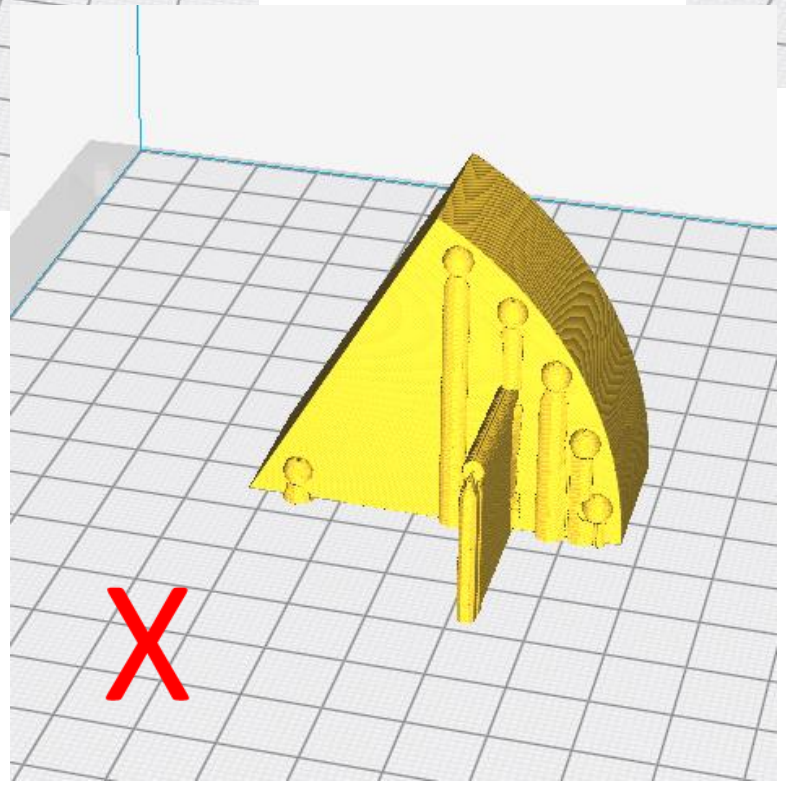
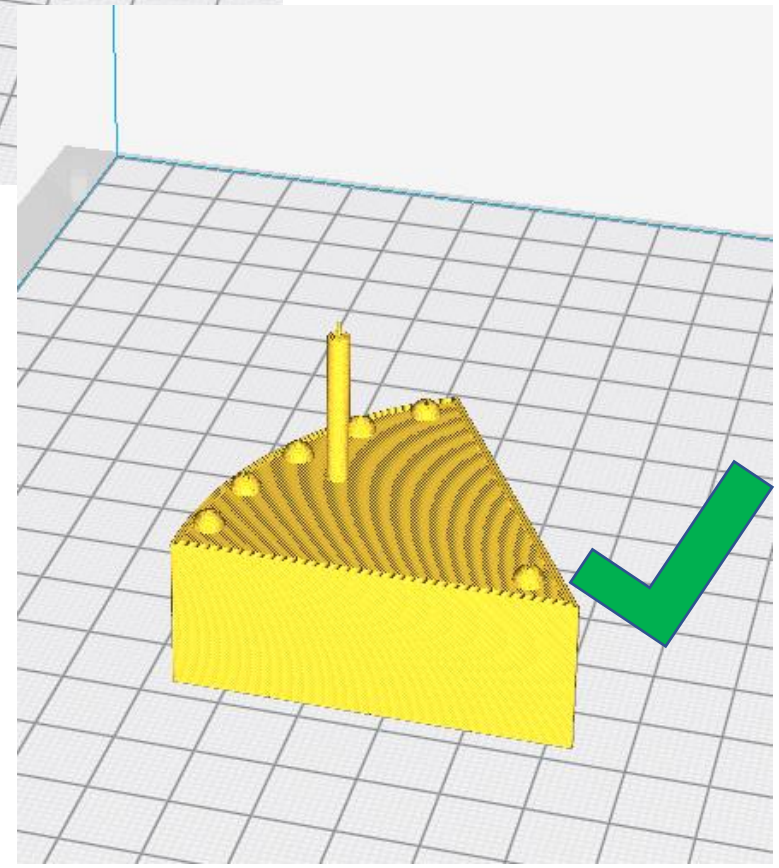
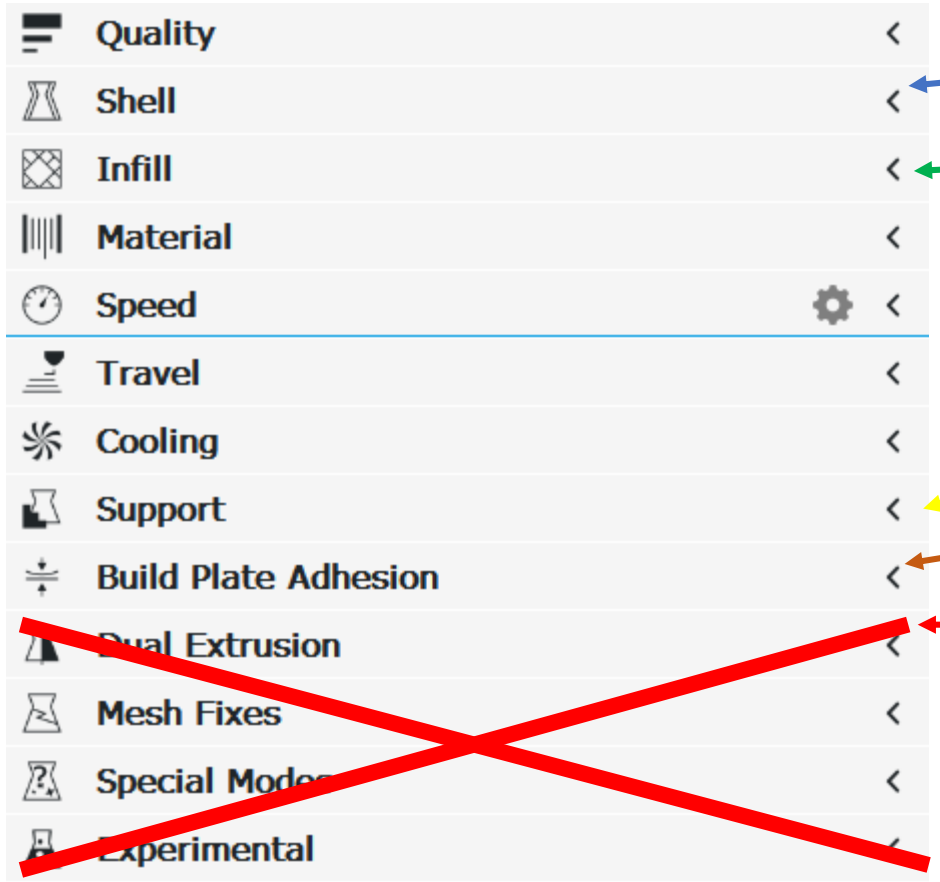

X



Cura – Important Print Settings



Number and thickness of outer wall(s)

Infill density (%) and structure

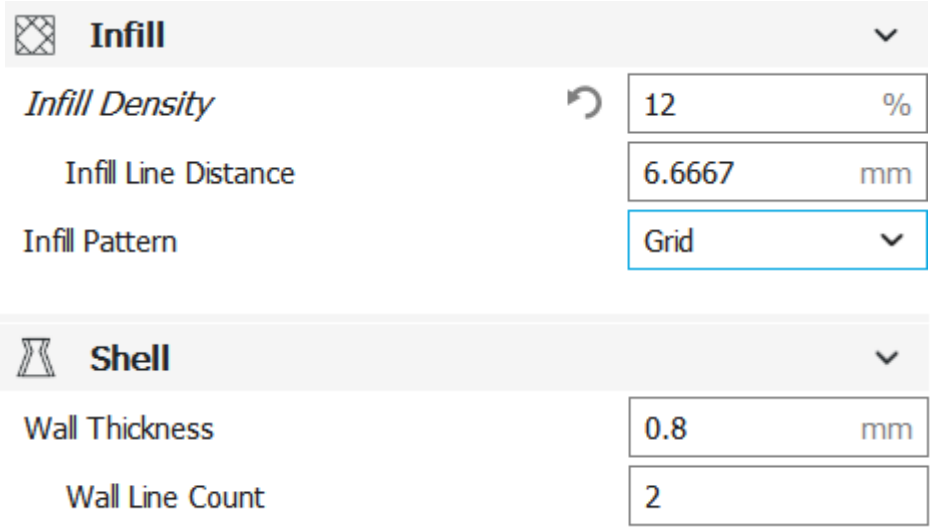
Generate Support (Y/N)
Structure/Stability of Support

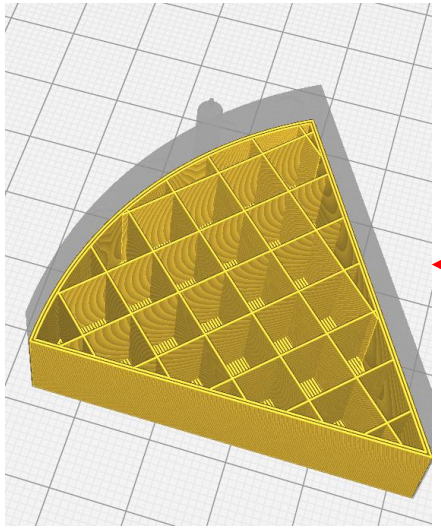
Generate build plate (Y/N)
build plate Structure

Doesn´t work with our printer: only one extruder

No idea what those are doing ;
Pretty complicated

Cura- Important Settings: Shell + Infill



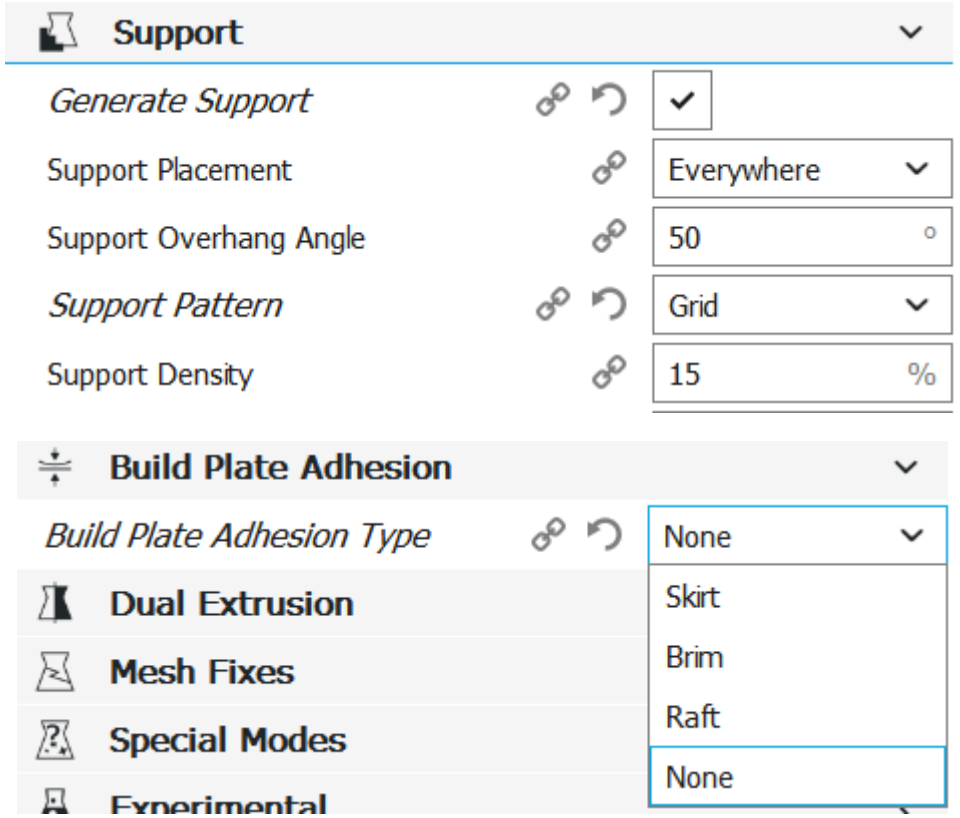


The cake model with the above settings (layer view)

- Outer Walls serve as main stability source
- 2-3 Walls usually suffice
- Infill density >10% suffices most of time
- More settings for both options
  - Either unimportant or are adjusted after changing the shown settings

Cura – Important Settings: Support & Build plate

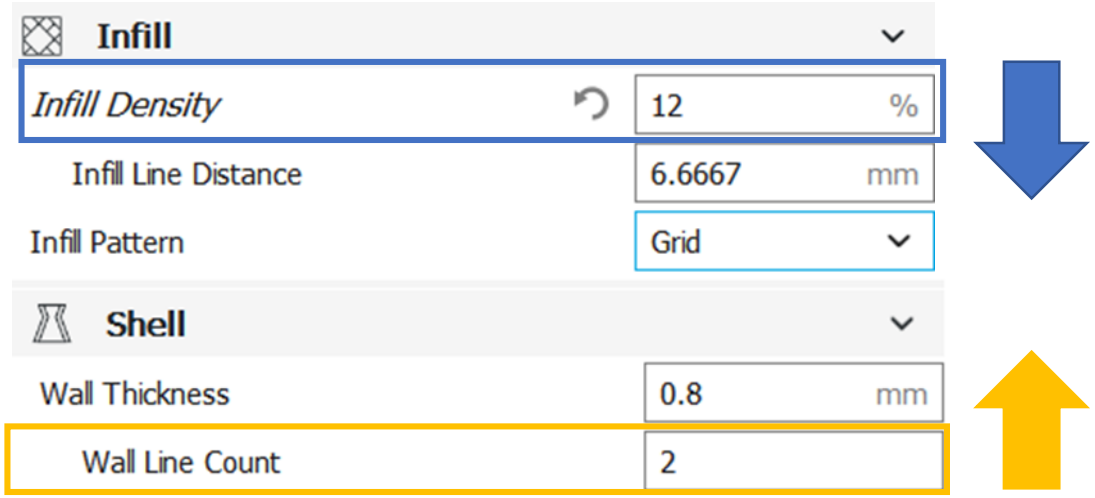
- Support:
  - needed by overhanging structures > 45°
  - Standard settings pretty ok
  - Leave checked unless stated in model description
- Build Plate:
  - Generates adhesion enhancing plate around/ under the model
  - Recommended for ABS
  - Raft is the strongest but biggest plate
- Both can be vied in “layer view”



Cura - finishing your file

- Check
  - Printing time
  - Printing weight
- Printing costs @ Krautspace
  - 0.50€ per print
  - Adittionally 0.04€/g
- Pres “Save to File” and name it
  - Include your (nick-)name, material, what you printed, weight, time
  - ex: GlaDos_PLA_cake_11g_2h23min.gcode
- Pay, Upload, Print

Reducing Print Costs



- Reduce infill percentage
  - Just add an extra outer layer
- Make your print smaller
- Avoid unnecessary support
- Avoid printing errors
  - Check Printer Calibration
  - **Stay till the printer has finished the first layer (or ask someone to watch it for you)**
    - Most prints go awry in the first few layers
  - Check back every few hours for longer prints (Telegram bot)

Choosing the right material

- High number of specialised Filaments
- Different physical and chemical properties

→ Different models require different Polymers

→ Settings and Handling have to be adjusted to the plastic used

Else…

(probably)


created with
OctoPrint

Common Filament Types

- Tested by us
  - PLA → Cheap biodegradable allrounder material
  - ABS → tough, heat resistant material
  - PET(G) → best known as everyday plastic for food safe containers

- Interesting but yet untested
  - TPU → similar to rubber
  - Conductive PLA→ low voltage circuits
  - Many many more …

PLA (Polylactic Acid)

= polymerized fermented maize starch

→ Biodegradable, environment friendly

+Easy to print

- Low printing temperature
- Almost no warping
- No adhesion plate/ glue necessary

- Brittle
- low Glass transition temperature (60°C)
- Low chemical resistance

ABS (Acrylonitrile butadiene styrene)

=

+ tough material

+ high glass transition temperature

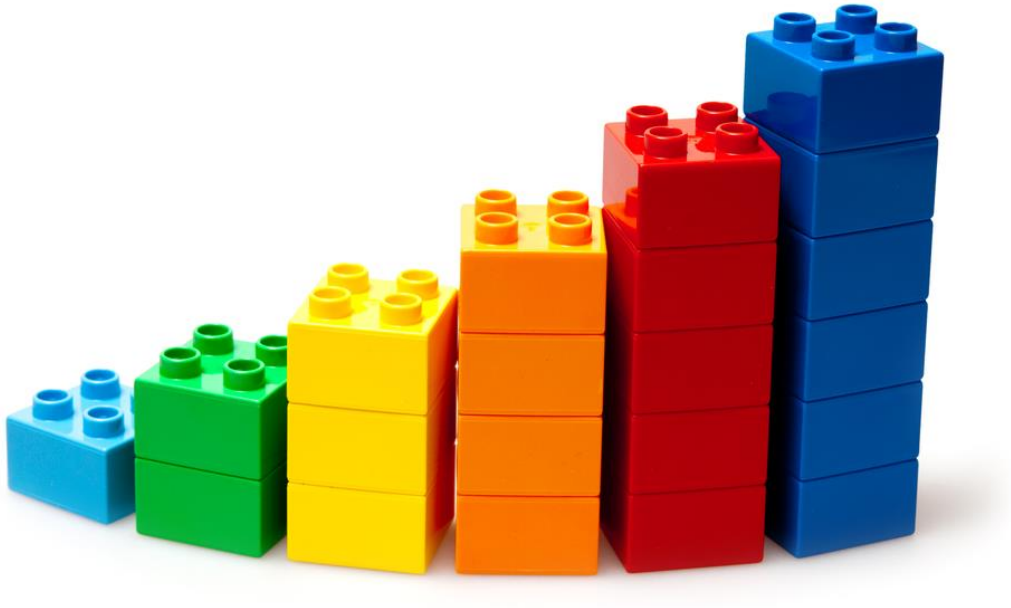
+ can be smoothed with acetone vapor

+ hydrolysis resistant

- Easily warps (up to 8%)

→ Ideal for small, fine objects, terrible for larger ones

Adhesion: diluted wood glue + build plate



PET(G) (Polyethylene terephthalate)

- “G” stands for glycolyzed

= commonly used, foodsafe polymer

+ low warping → used for bigger prints

+ high melting()/ glass transition point ()

+almost no warping

- small scale printing artefacts
- Small details and support often undistinguishable

- Adhesion: diluted wood glue

(Re)calibrating the printer

- Use Octoprint to Home the printer on all axes
  - Make sure the marked lines at both threaded rods are at 6´o clock (always)
  - Put a paper sheet between plate and extruder then try to move it around

    (after failed prints)

  →If its possible to move it with some resistance the its well calibrated
    - Check all edges and corners, make sure it doesn't get harder/ easier
    - Adjust using a screw driver on the plates corner screws