Basics of CAD Modeling with Autodesk Fusion 360 and 3D Printing

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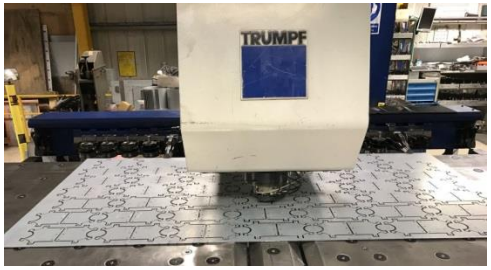
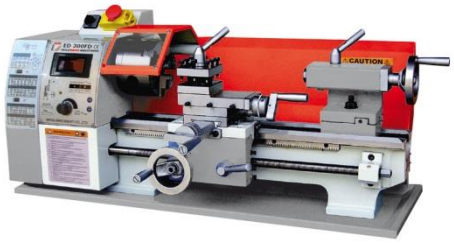
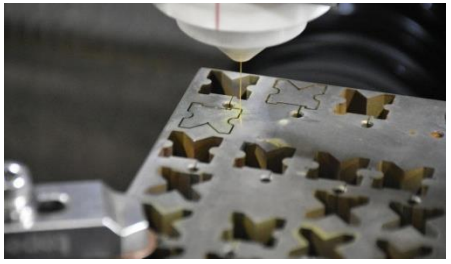
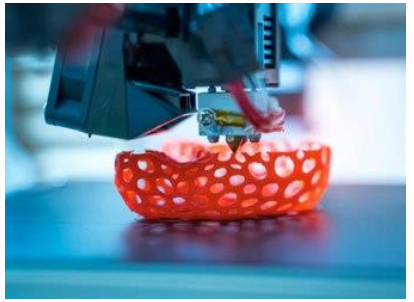
What is 3D printing and why you should care

- Branch of CNC machining (computer numerical control)
  - Automated control of a machining tool
    - Drills, Lathes, Mills, Punchers, Plasmacutters, Water-Jet Cutters, EDM, 3D Printers and many more



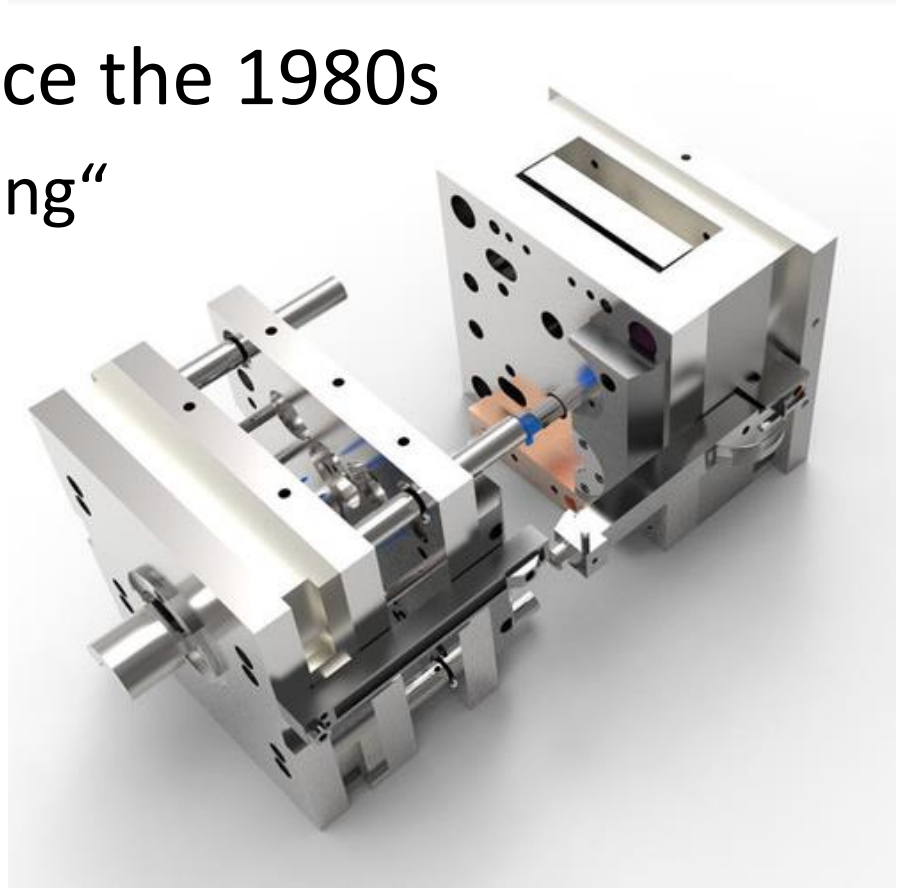


What is 3D printing and why you should care

- Additive Manufacturing
  - Material is applied instead of removed
- Under development since the 1980s
  - Termed „rapid prototyping“



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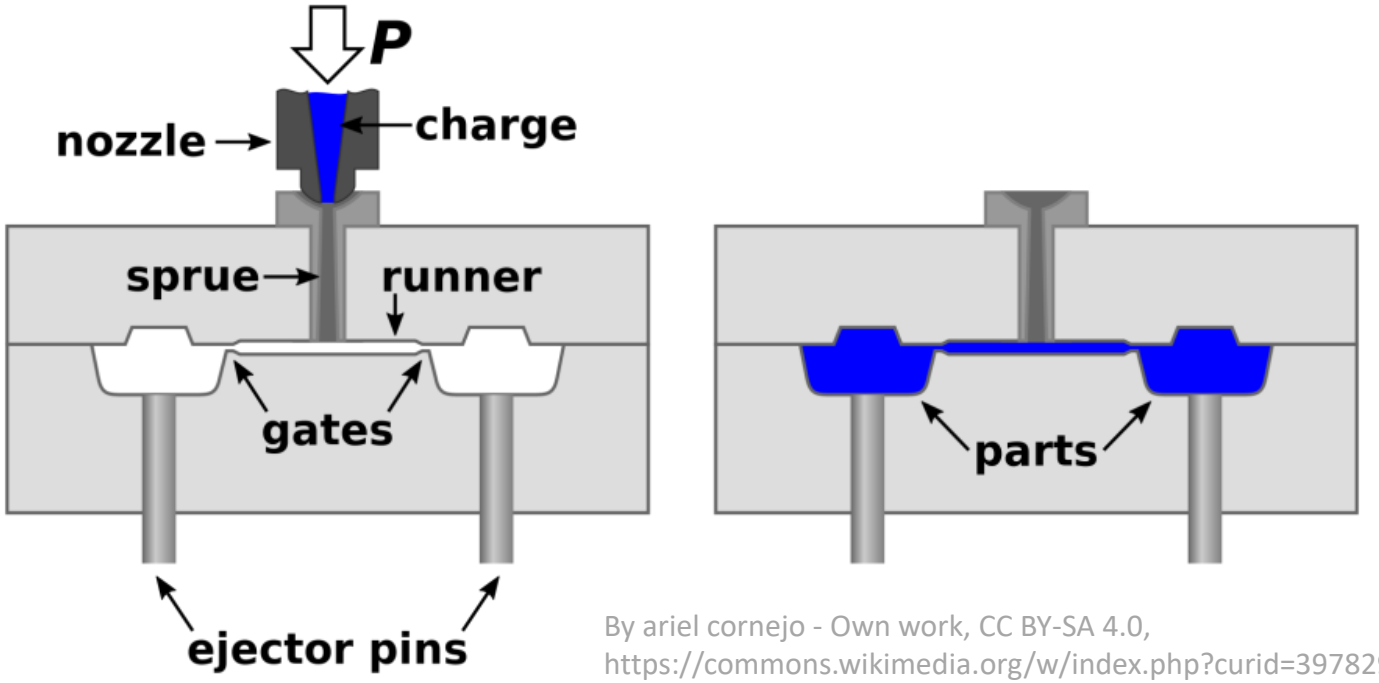

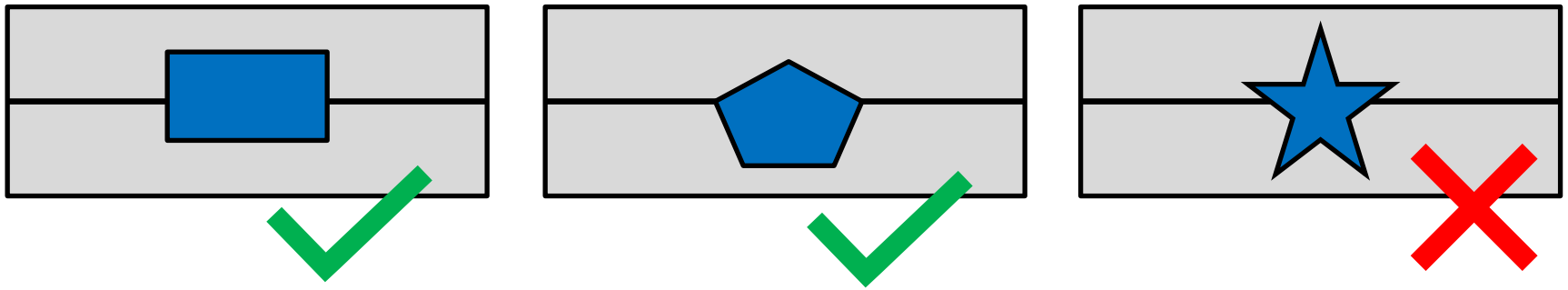

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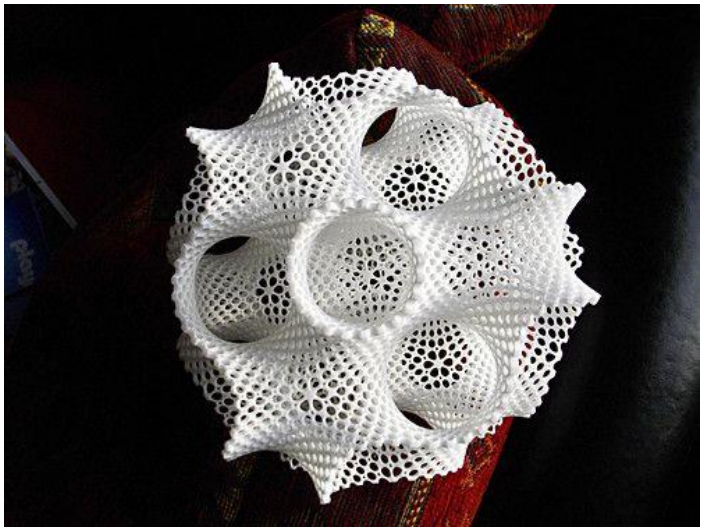
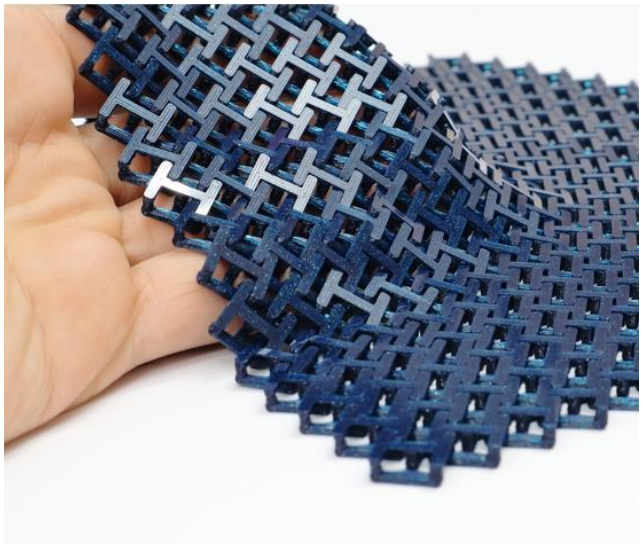
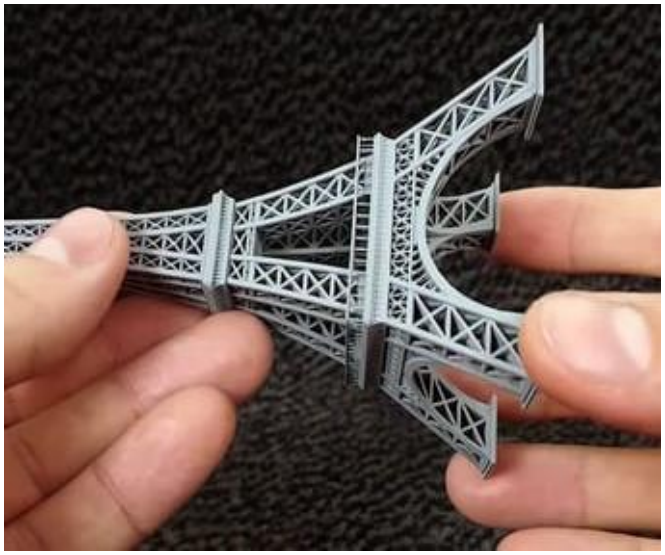
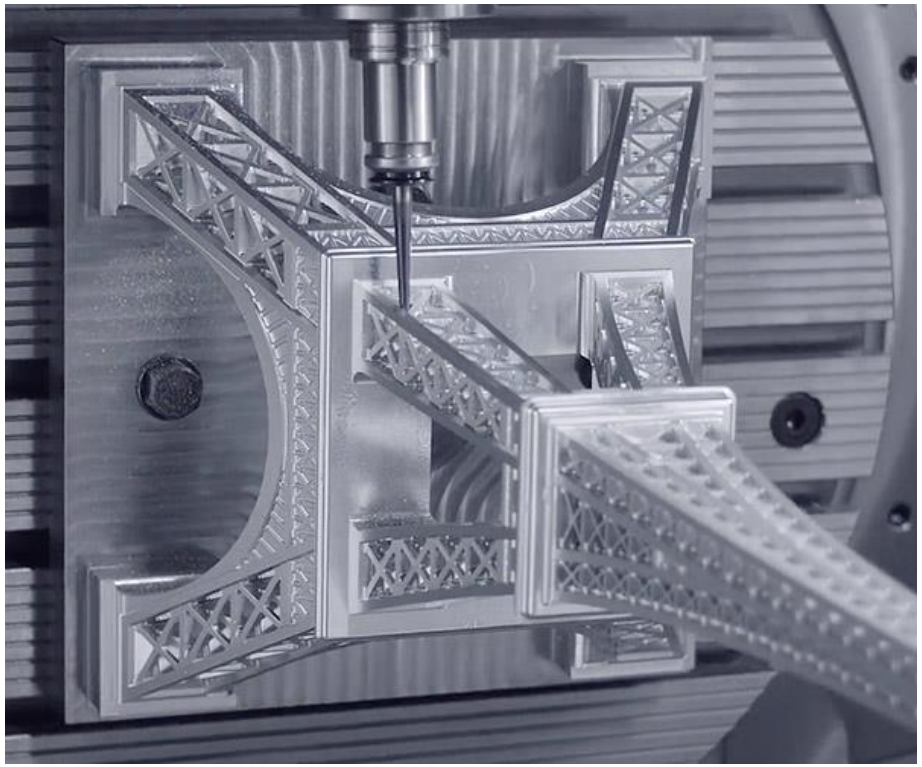






What is 3D printing and why you should care

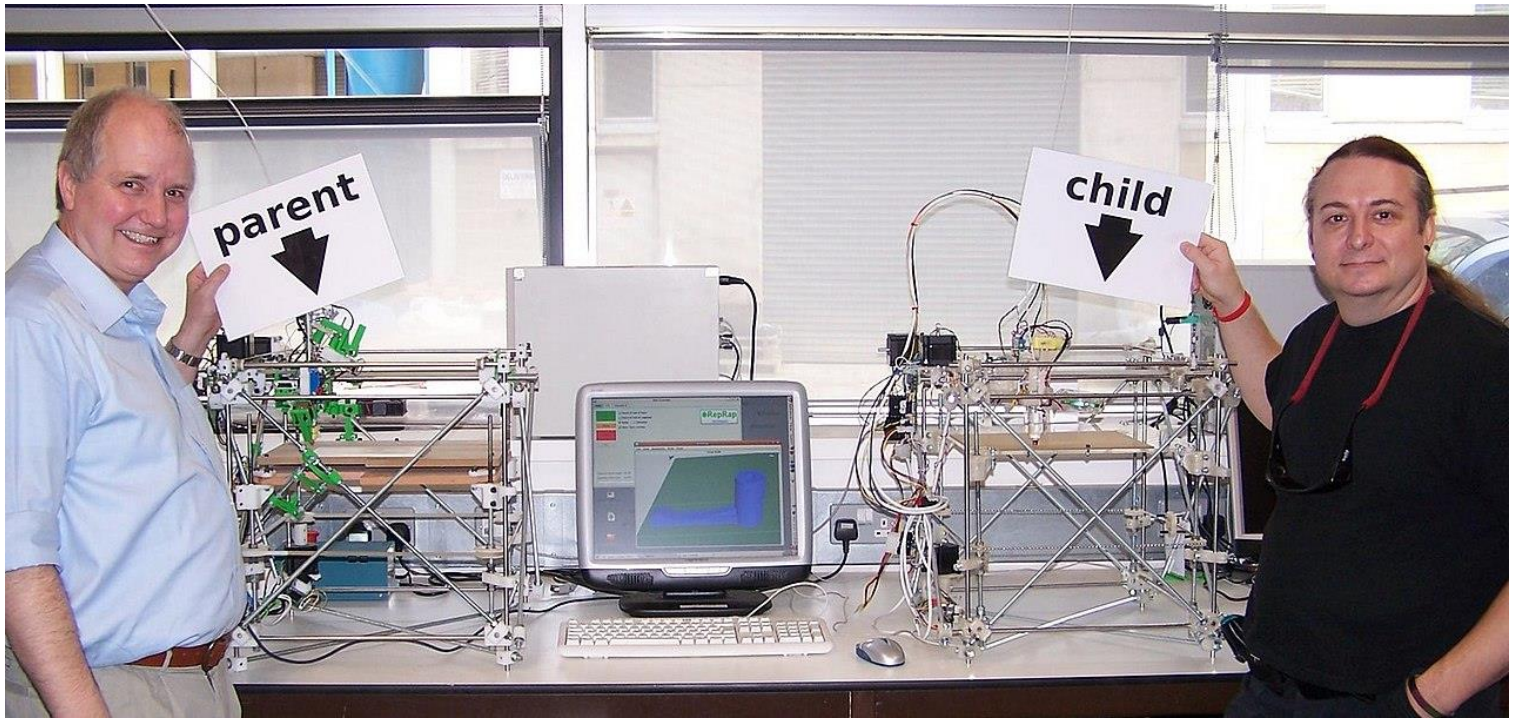
~ $50.000 - $100.000



~ $200 - $2000

What is 3D printing and why you should care

- What made 3D Printing so accessable?
  - 2005 Start of the Replicating Rapid prototyper project



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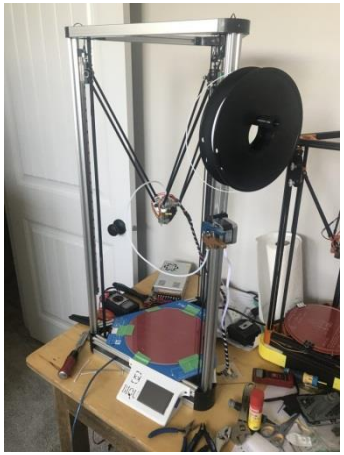
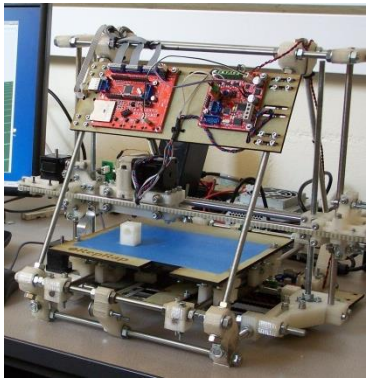
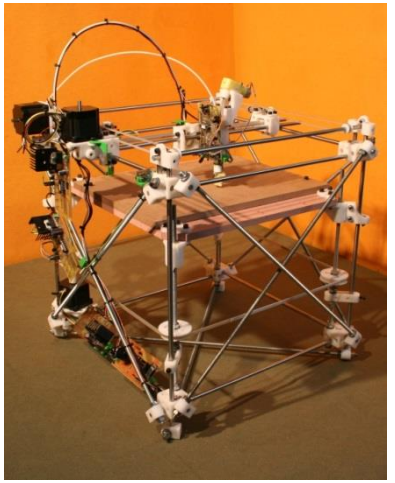
Prusa_i3



Delta Printers



RepRap Mendel



RepRap Darwin

What is 3D printing and why you should care

Creality Ender 3

Biqu b1

Alfawise u30

Tronxy xy-2

Longer lk4

Geeetech a10

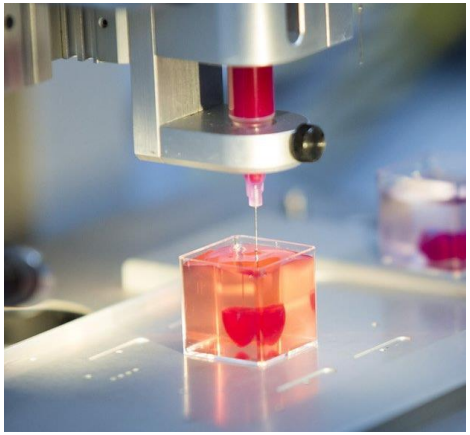
What is 3D printing and why you should care

Creality Ender 3

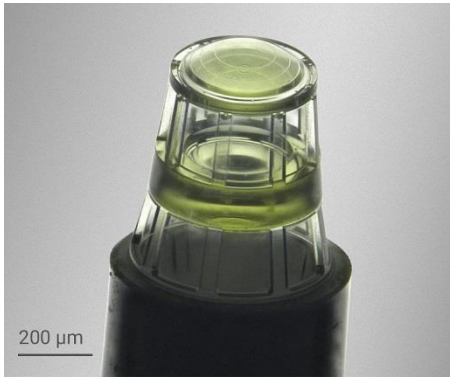
Formlabs Form 2

Relativity Space Stargate

PERI Concrete Printer



Bioprinters



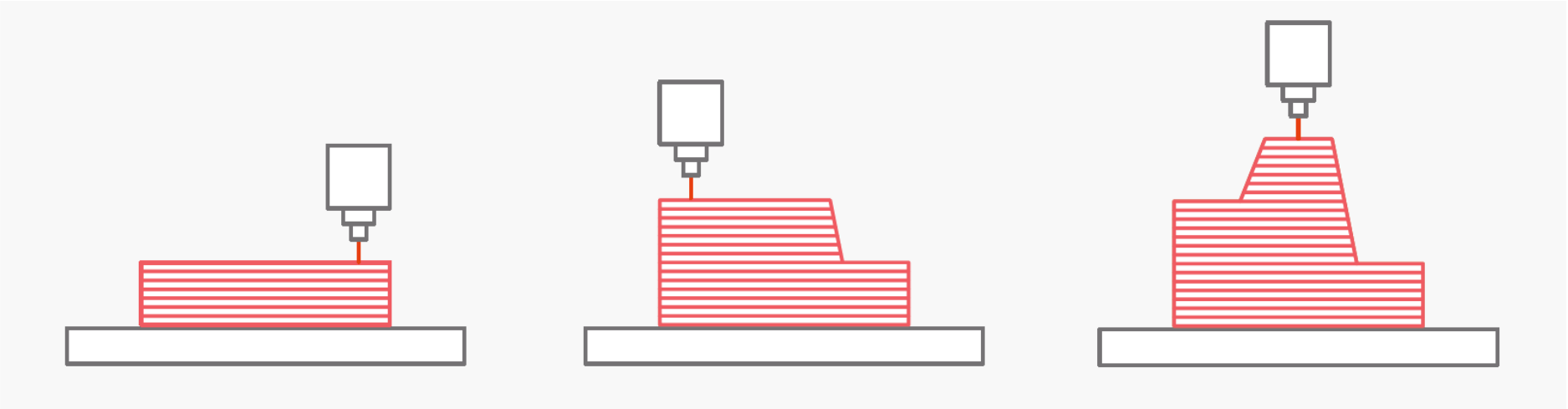
Nanoscribe

What is 3D printing and why you should care

- 3D printing blends into every aspect of our every day life
- Increasing Accessiblity
  - Printers and printing materials more affordable
- Opens new ways of thinking

How 3D printing works

- Start on a Build plate
- Object is constructed layer by layer



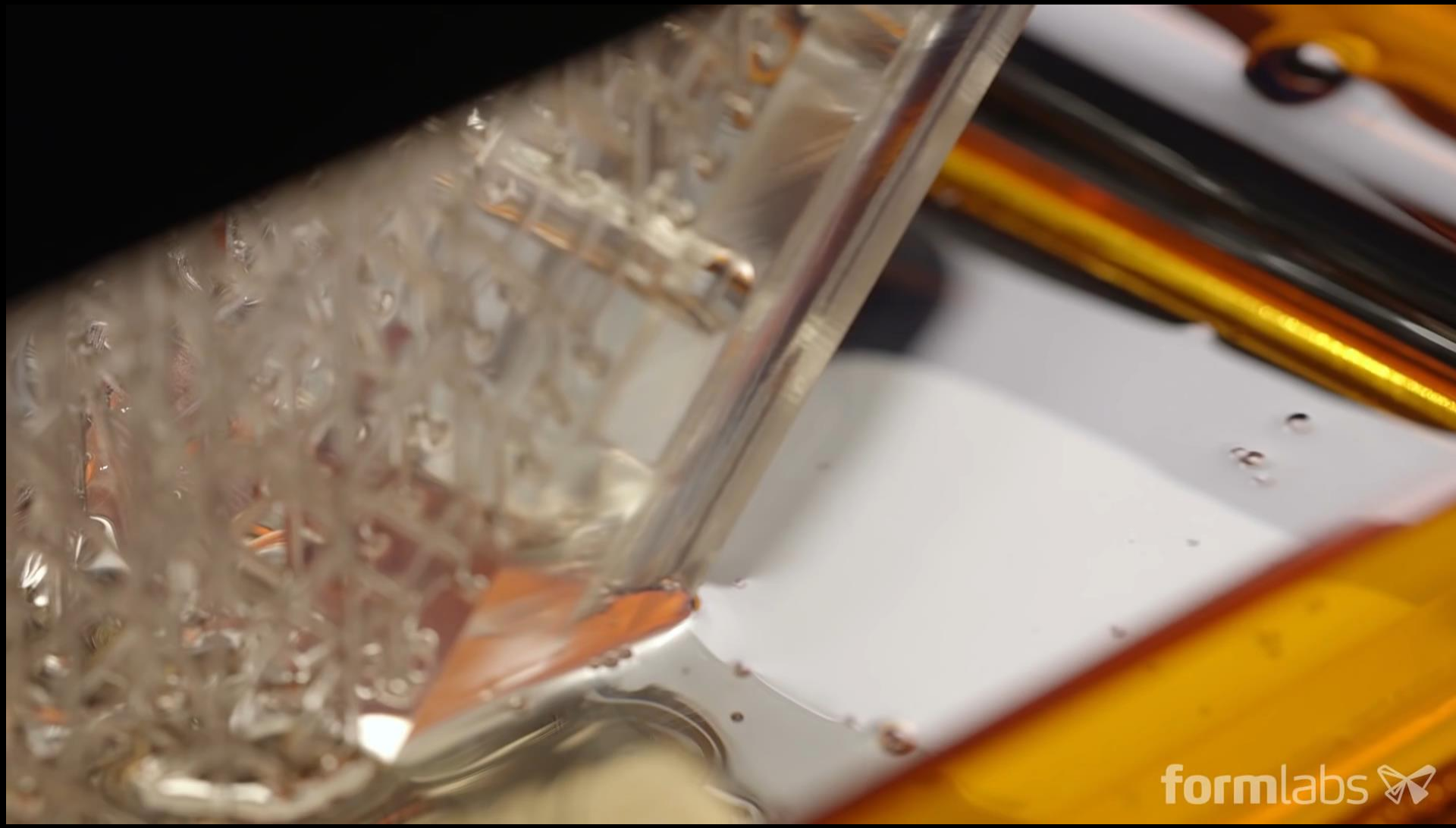
How 3D printing works

- FDM Printer:
  - **F**used **D**eposition **M**odeling
  - Plastic Filament as Printing Material
  - Material melted at Hotend and pushed forward with a motor – the Extruder
    - Similar to a glue gun
  - Nozzle „draws“ model cross-sections by placing thin lines of molten plastic on previous layers
    - Overhangs need extra support
  - Weaker along building axis – non isotropic


SOLID CONCEPTS

How 3D printing works

- SLA and mSLA Printer:
  - (**m**asked) **S**tereo**l**ithography **A**pparatus
  - UV-sensitive polymer Resin as printing material
    - Resin monomers polymerize upon UV exposure
  - Buildplate decends into liquid resin
    - Model built upside down from bottom of the buildplate
  - Cross-section either cured by laser beam (SLA) or by illumination of the entire area at once (mSLA)
  - Models need to be washed and cured after printing
  - Isotropic properties
  - Very fine details possible


formlabs

How 3D printing works

Comparison FDM and SLA

FDM

+ Quick and few post processing steps required
+ Good for large and structural parts like cases and frames
+ Parts are lightweight and sturdy
– Reduced stability along z-axis
– Lower XY-resolution compared to SLA
– Difficult to get watertight
– More moving parts than SLA

SLA

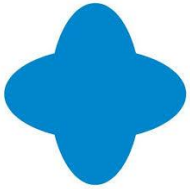
+ Very high level of detail
+ Ideal for small and complex parts
+ Reliable watertightness
+ Isotropic properties
– Washing and curing required
– Resin is usually more expensive
– Uncured resin is hazardous
– Parts with high volume need to be printed hollow

The Slicer

- Every 3D printing technique needs a slicer
- Link between computer and printer
- Very high customizability of the print
- Many different host interfaces / slicers available:
  - Cura, Pronterface, Repetier Host, Prusa Slicer,



Preform, Chitubox, Flashprint


The Slicer

- Translates the model geometry into G-code
- G-code is a repository of commands the firmware of a CNC machine can understand:
- Every model is translated into a sequence of gcodes lines that the machine runs until print is finished

G-code	meaning
G1 X0 Y0 Z0	Move print head to Coordinates 0,0,0
G28	Move all axes to their Min-endstop
M92 X300	Set X-axis steps per rotation to 300
M104 230	Set hotend temperature to 230°C
M500	Save changes to EEPROM

The Slicer

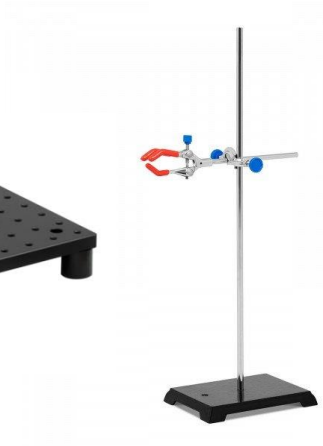
```
%
(Header)
(Generated by gcodetools from Inkscape.)
(Using default header. To add your own header create file
"header" in the output dir.)
M3
(Header end.)
G21 (All units in mm)

(Start cutting path id: path29632)
(Change tool to Cylindrical cutter)

G00 Z5.000000
G00 X33.655106 Y11.817060

G01 Z-1.000000 F100.0(Penetrate)
G01 X247.951560 Y11.817060 Z-1.000000 F400.000000
G01 X247.951560 Y30.935930 Z-1.000000
G01 X106.963450 Y30.935930 Z-1.000000
G03 X106.587404 Y32.243414 Z-1.000000 I-7.576860 J-1.471361
G03 X105.974610 Y33.458880 Z-1.000000 I-6.445333 J-2.487300
G03 X104.697090 Y35.083261 Z-1.000000 I-7.601246 J-4.663564
G03 X103.141830 Y36.435630 Z-1.000000 I-10.087550 J-10.030472
G03 X102.969400 Y38.107779 Z-1.000000 I-20.252028 J-1.243405
G03 X102.369430 Y39.685740 Z-1.000000 I-3.842423 J-0.557919
G03 X100.419761 Y41.664361 Z-1.000000 I-6.181245 J-4.140917
G02 X98.333794 Y43.482560 Z-1.000000 I7.045018 J10.188229
```

Practical part

- Designing a part
  - Preconsiderations
  - Measuring precisely
  - Make a draft
- CAD design
- Print with Flashforge Creator 3
- Print with Formlabs Form 2
- Outlook

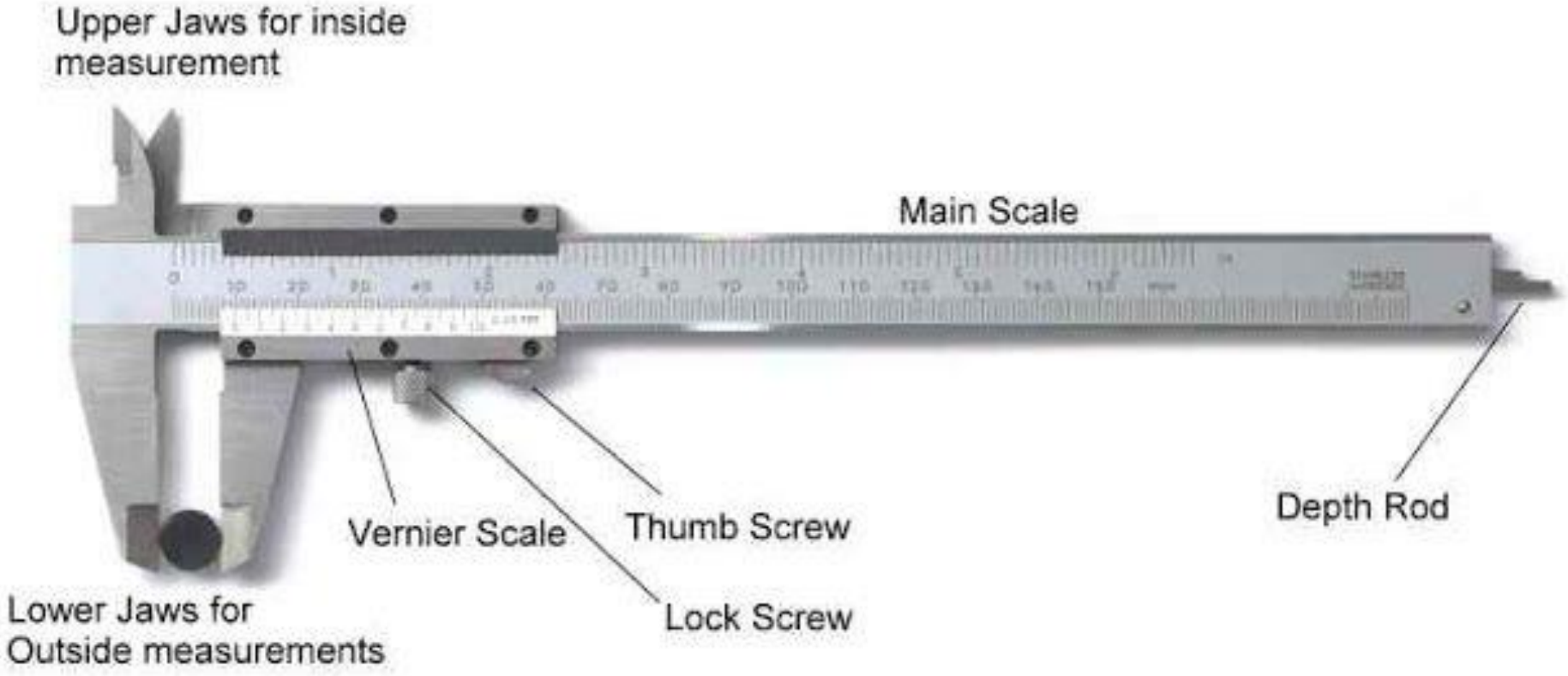
How to design 3D objects Preconsiderations

- 3D printed parts commonly attached to surfaces
  - Thorlabs breadboards, supports, connectors, screwholes, aluminum profiles and more

  - Geometries must be measured accurately to fit
  - ideal case: print fits perfectly. no excessive play or force needed to attach. no redesign

How to design 3D objects accurate measurements



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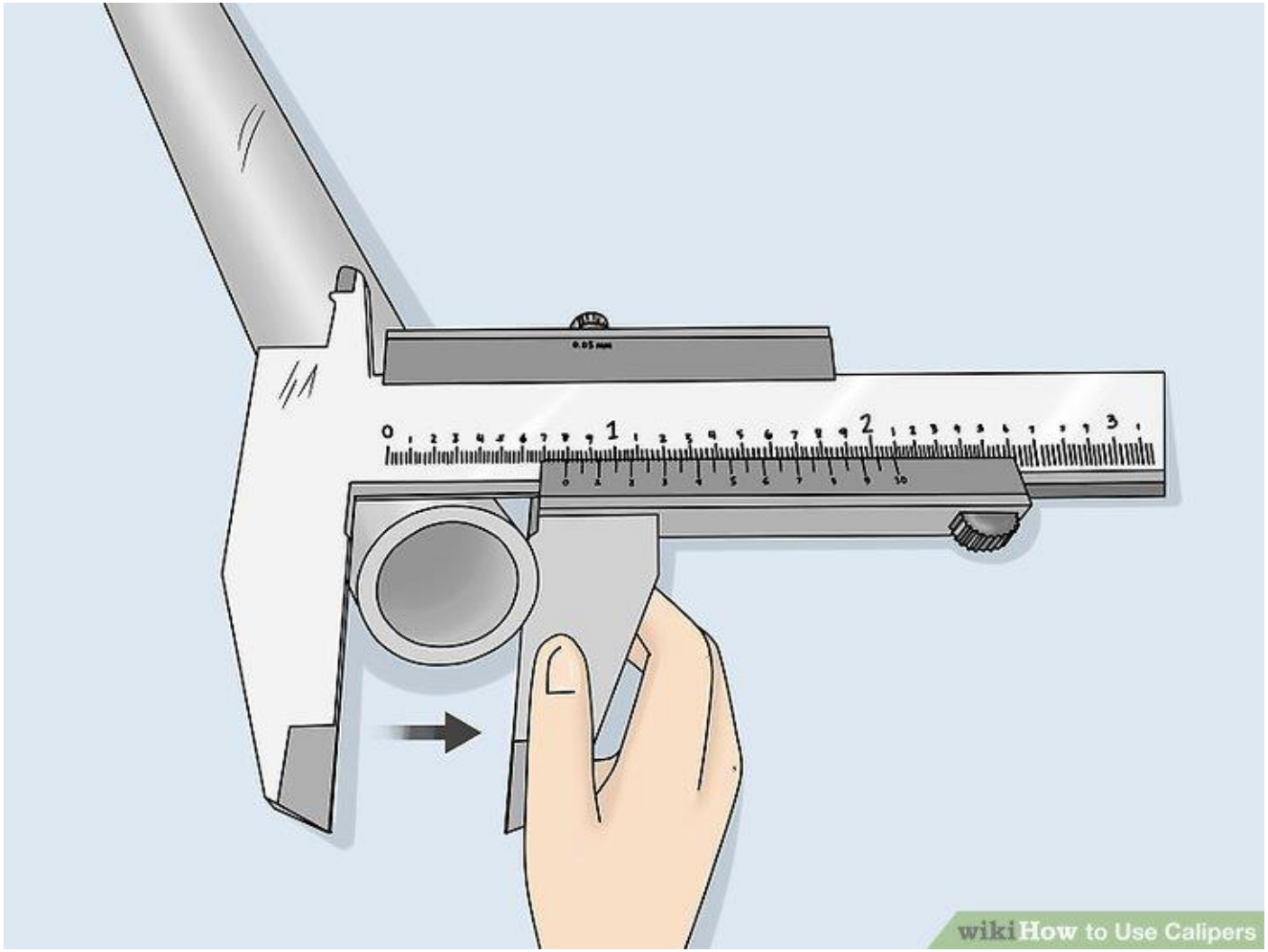

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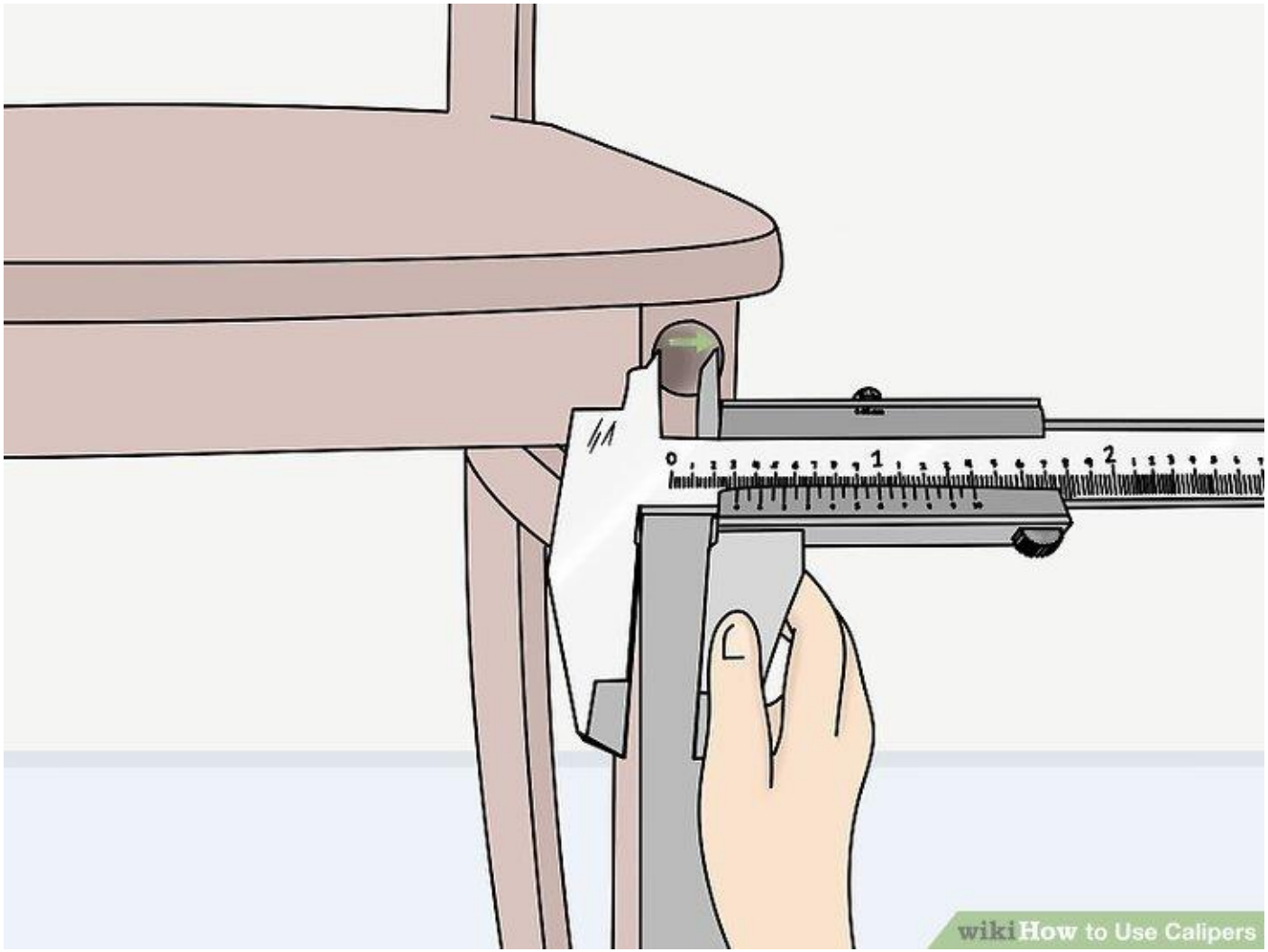

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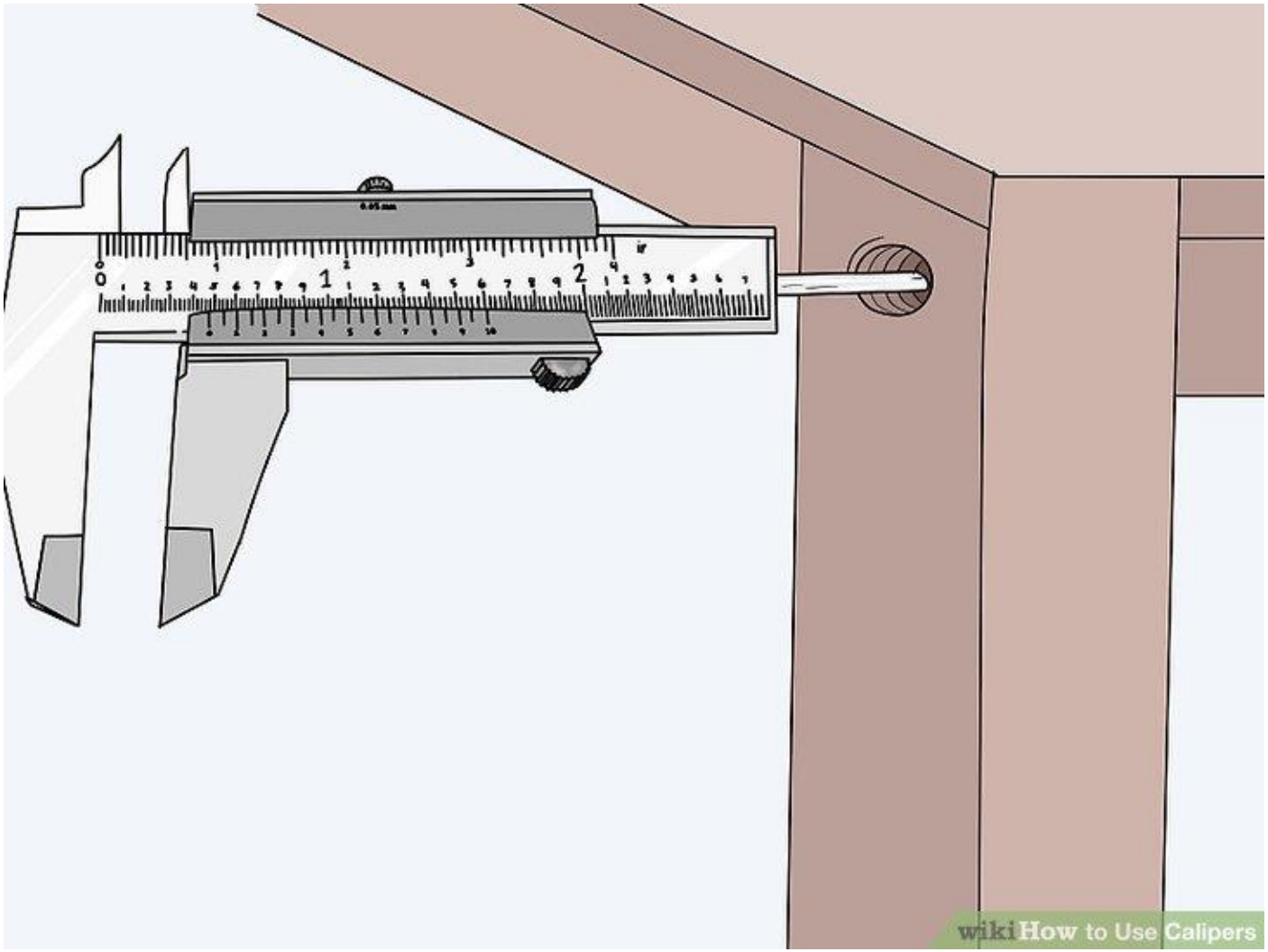
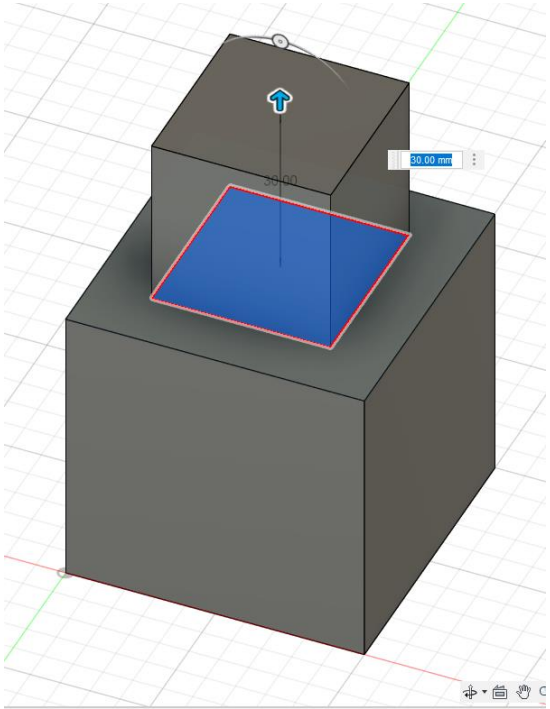


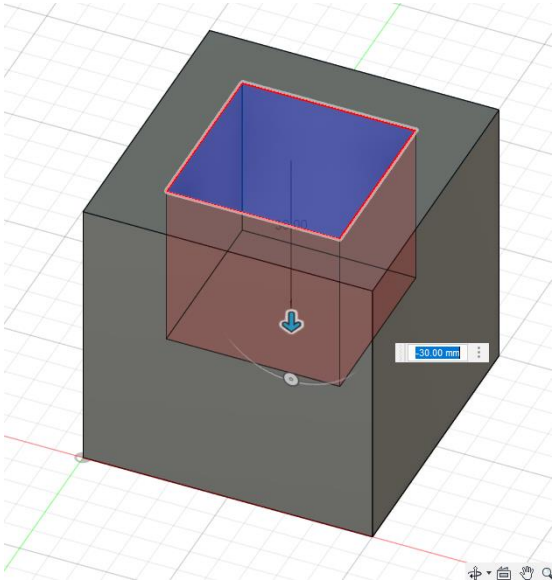
How to design 3D objects
CAD Basics

- CAD = Computer aided design
  - made for Computer aided machinery
  - helpful for making changes
  - Quick
- sketch: closed geometry to use for further manipulation
- constraints: decrease a geometries degree of freedom
- Volume: uses sketch to add to or remove from existing geometry

How to design 3D objects
CAD Basics

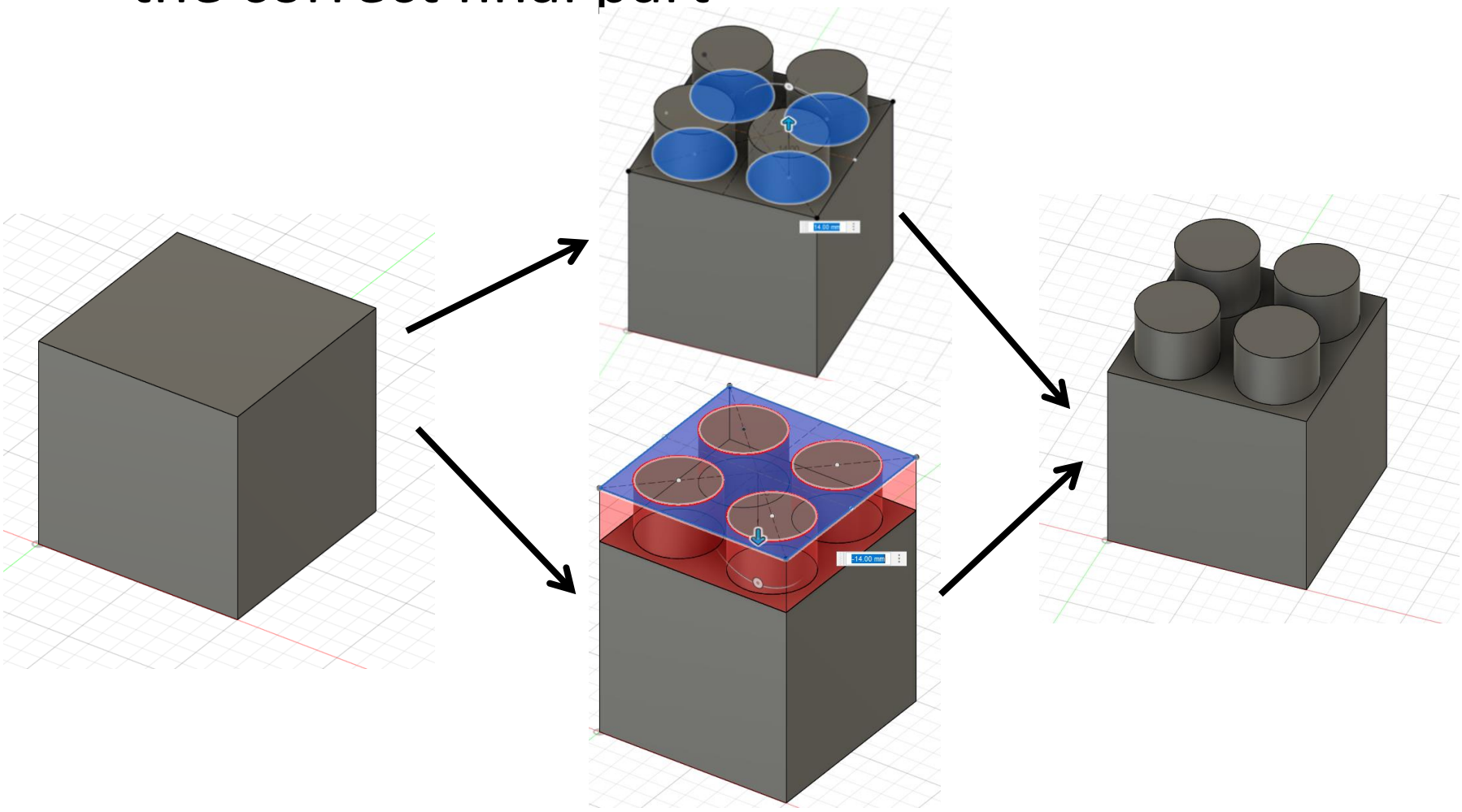
- In CAD closed geometries are extruded to form volumes
  - Volumes can be applied to add or subtract an existing volume





How to design 3D objects
CAD Basics

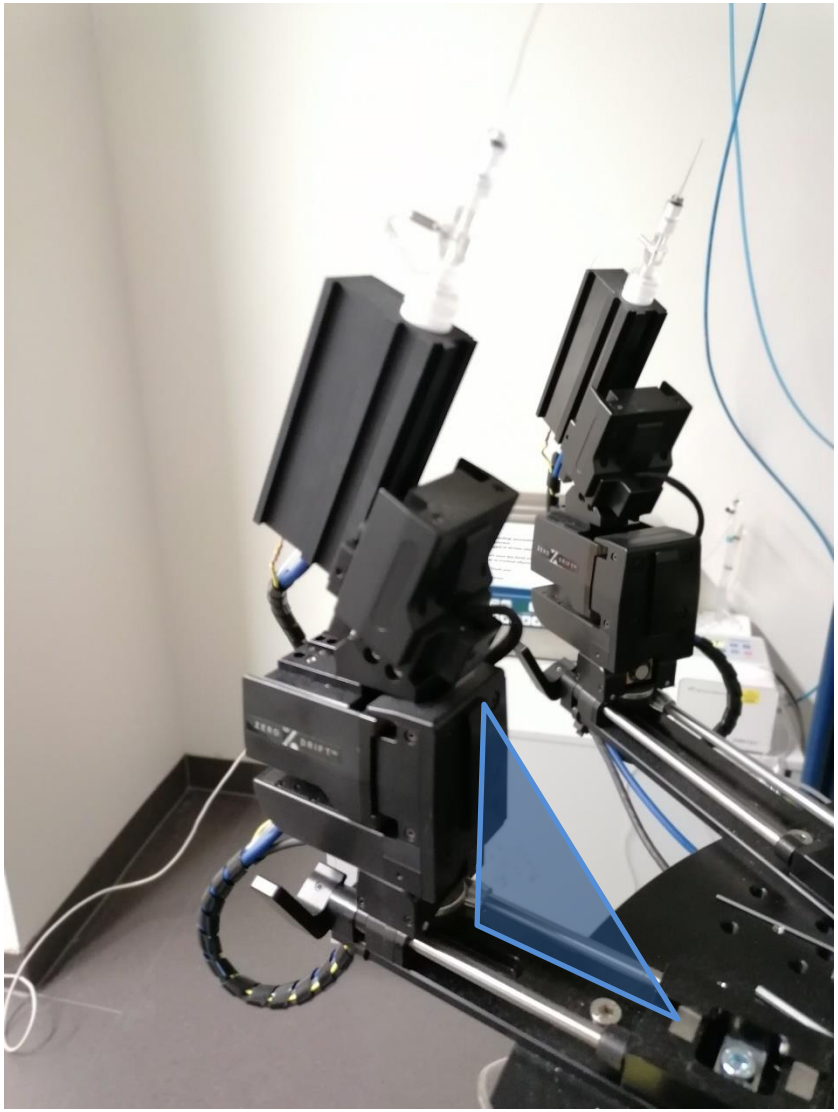
- different modelling approaches can lead to the correct final part



How to design 3D objects
Fusion 360

- good example for well engineered CAD
- good for demonstrating basics of CAD modelling
- HU and Charite Accounts can be used to acquire free educator or student access
- Alternatives:
  - Solidworks, Inventor, Blender, FreeCAD, openSCAD, TinkerCAD

How to design 3D objects
The draft



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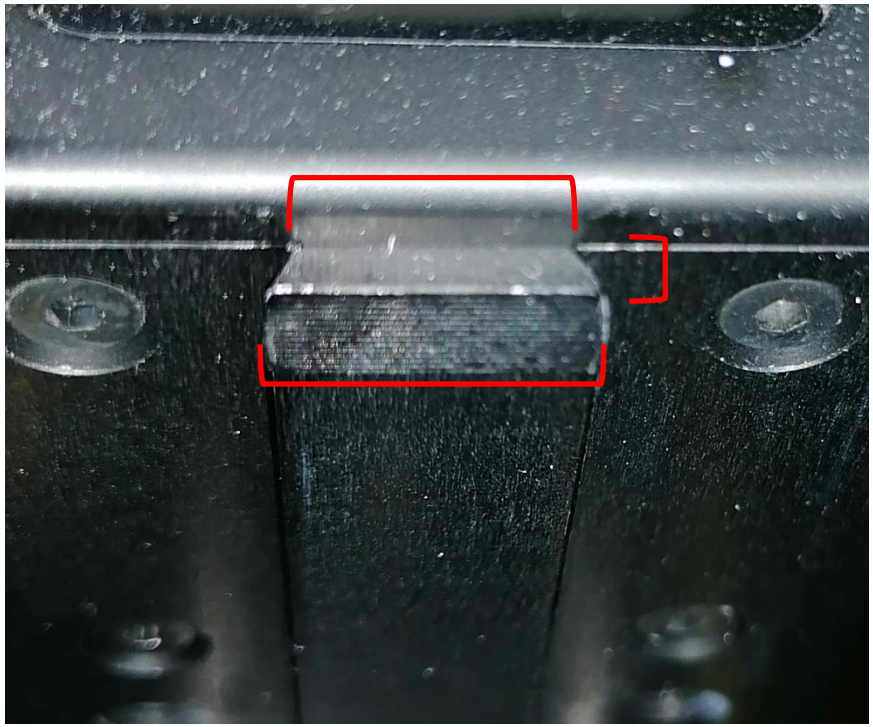

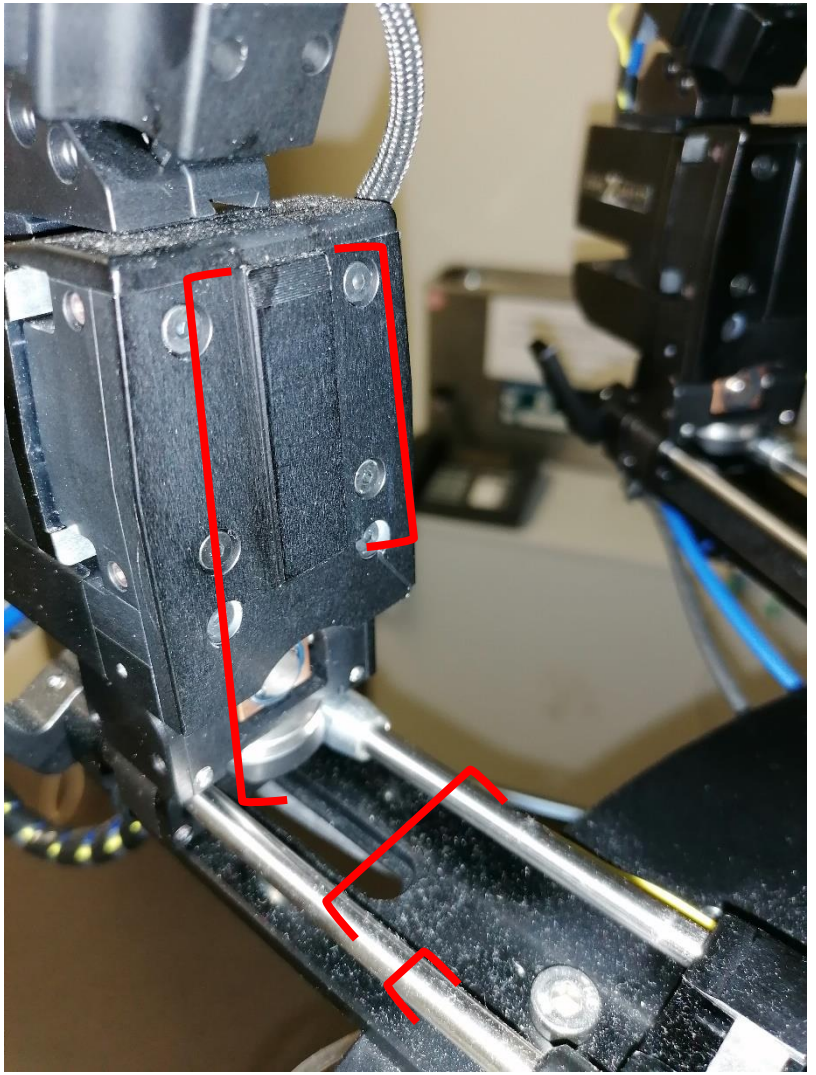

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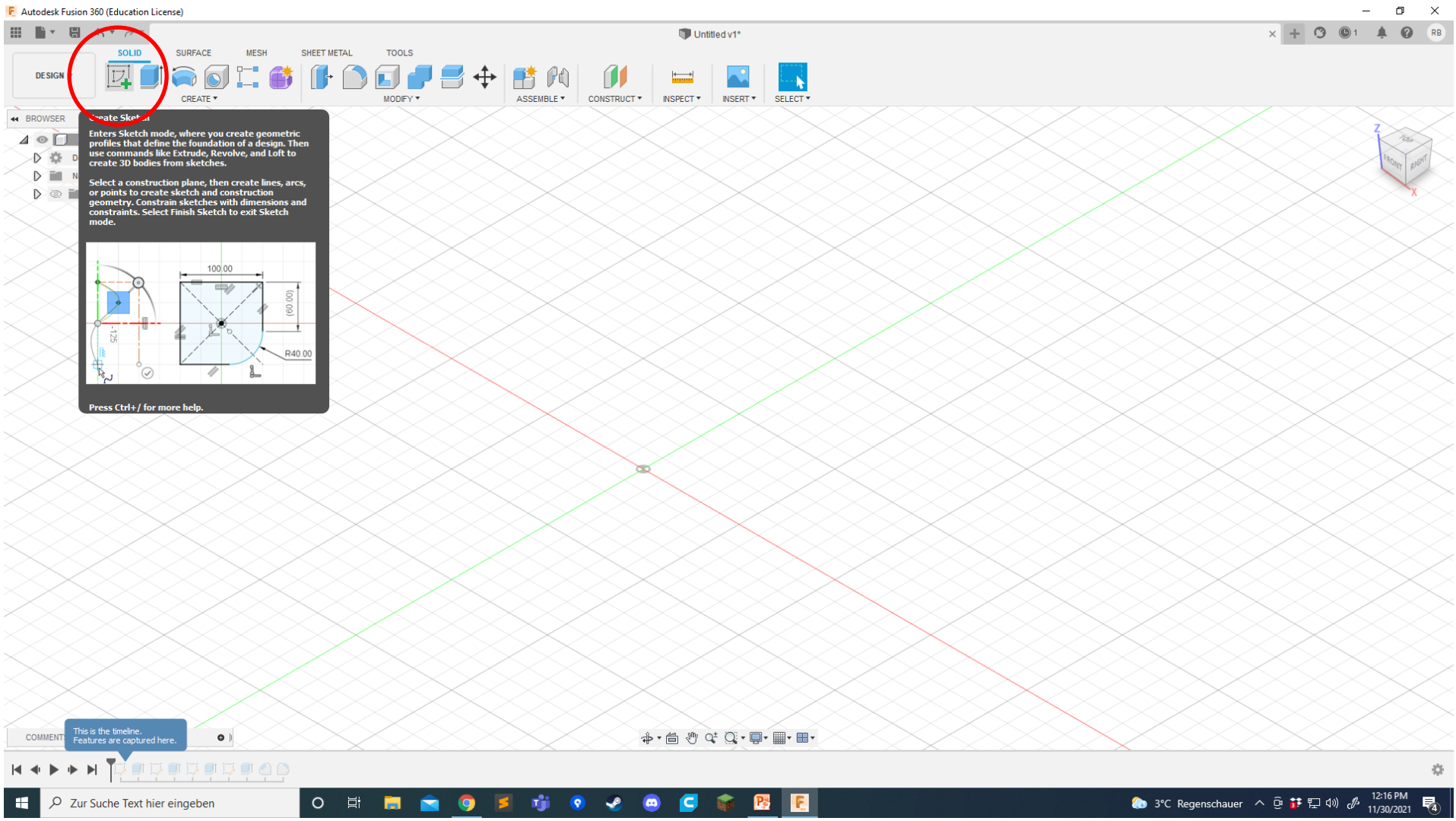

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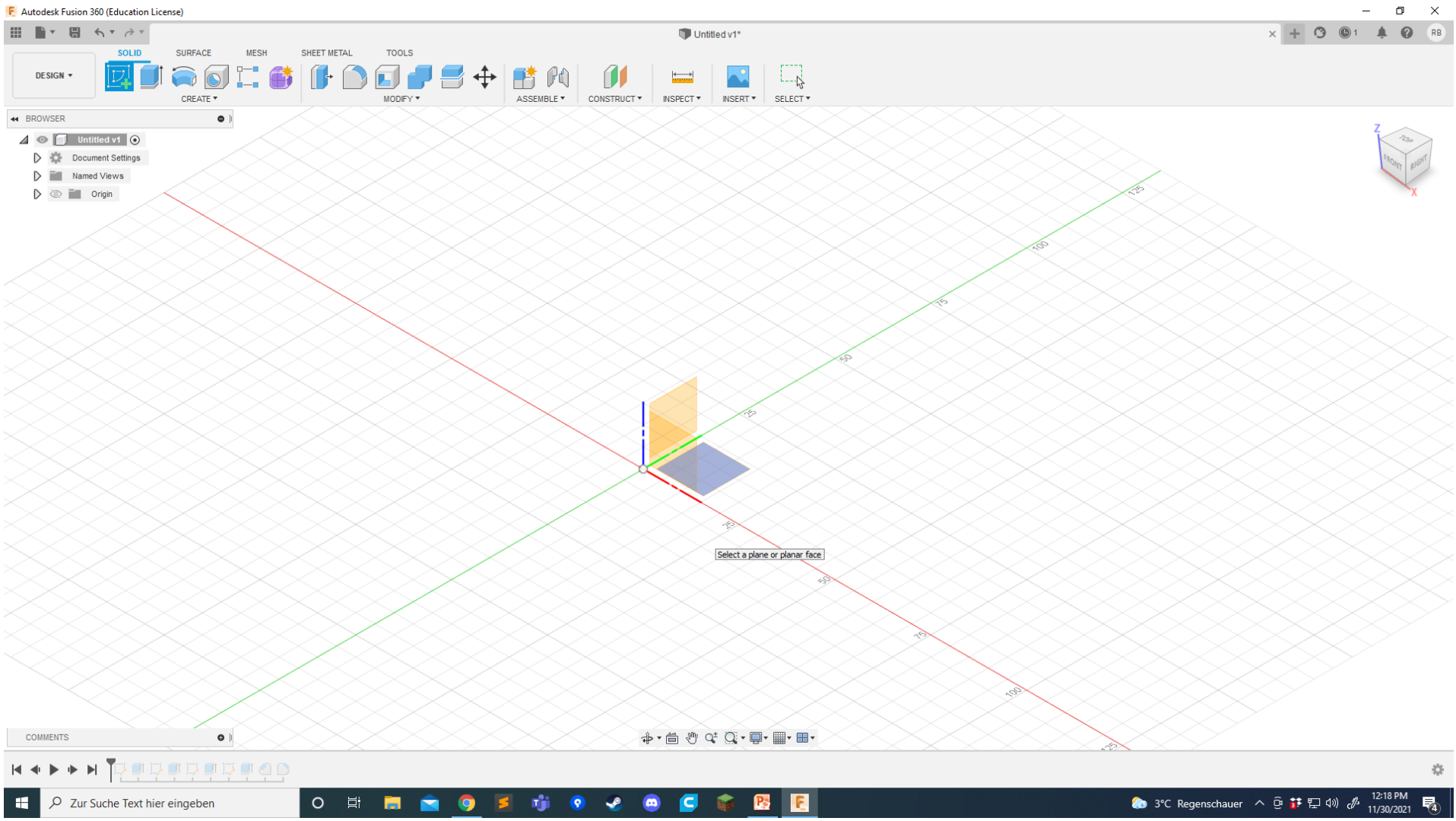

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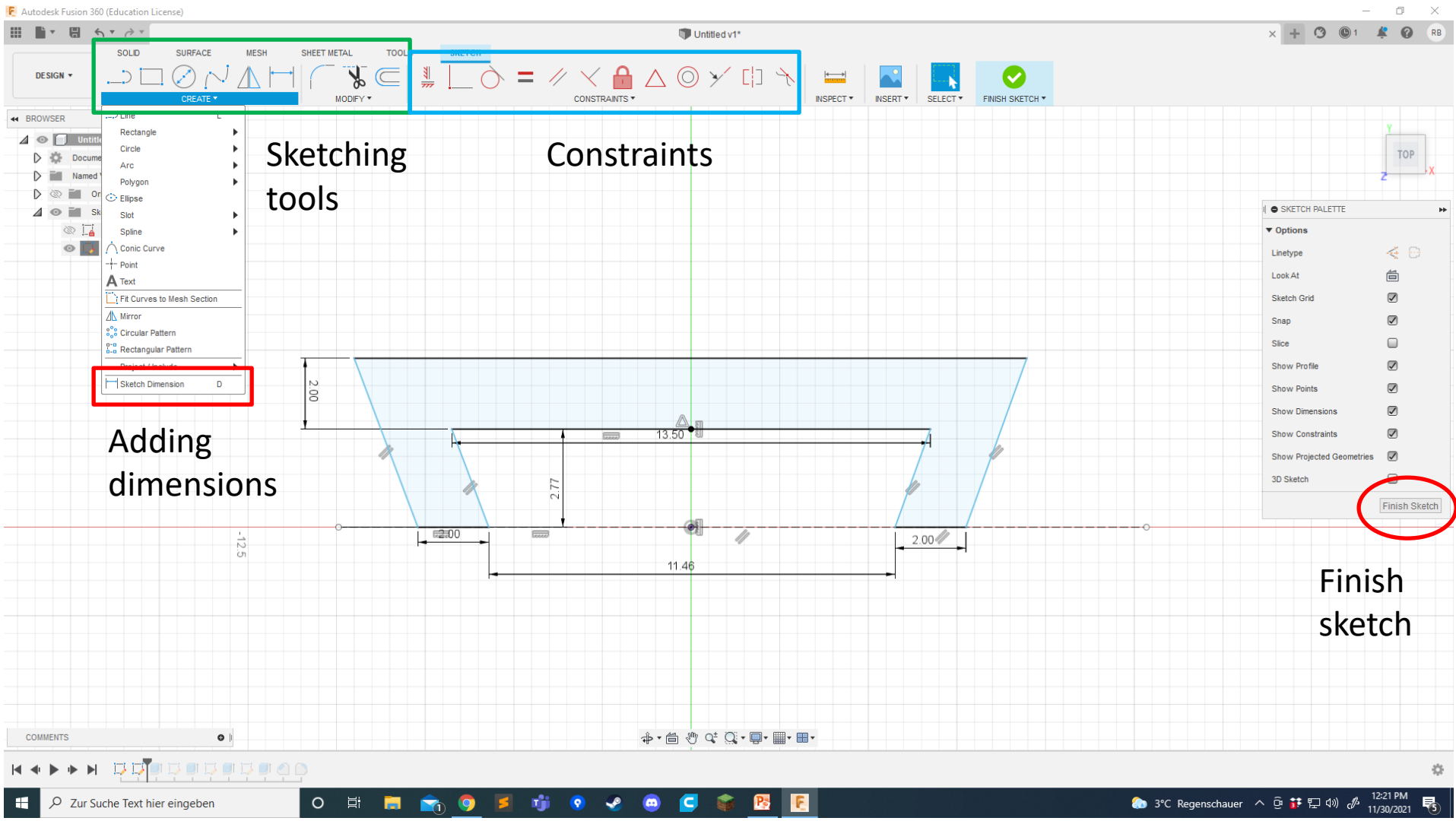

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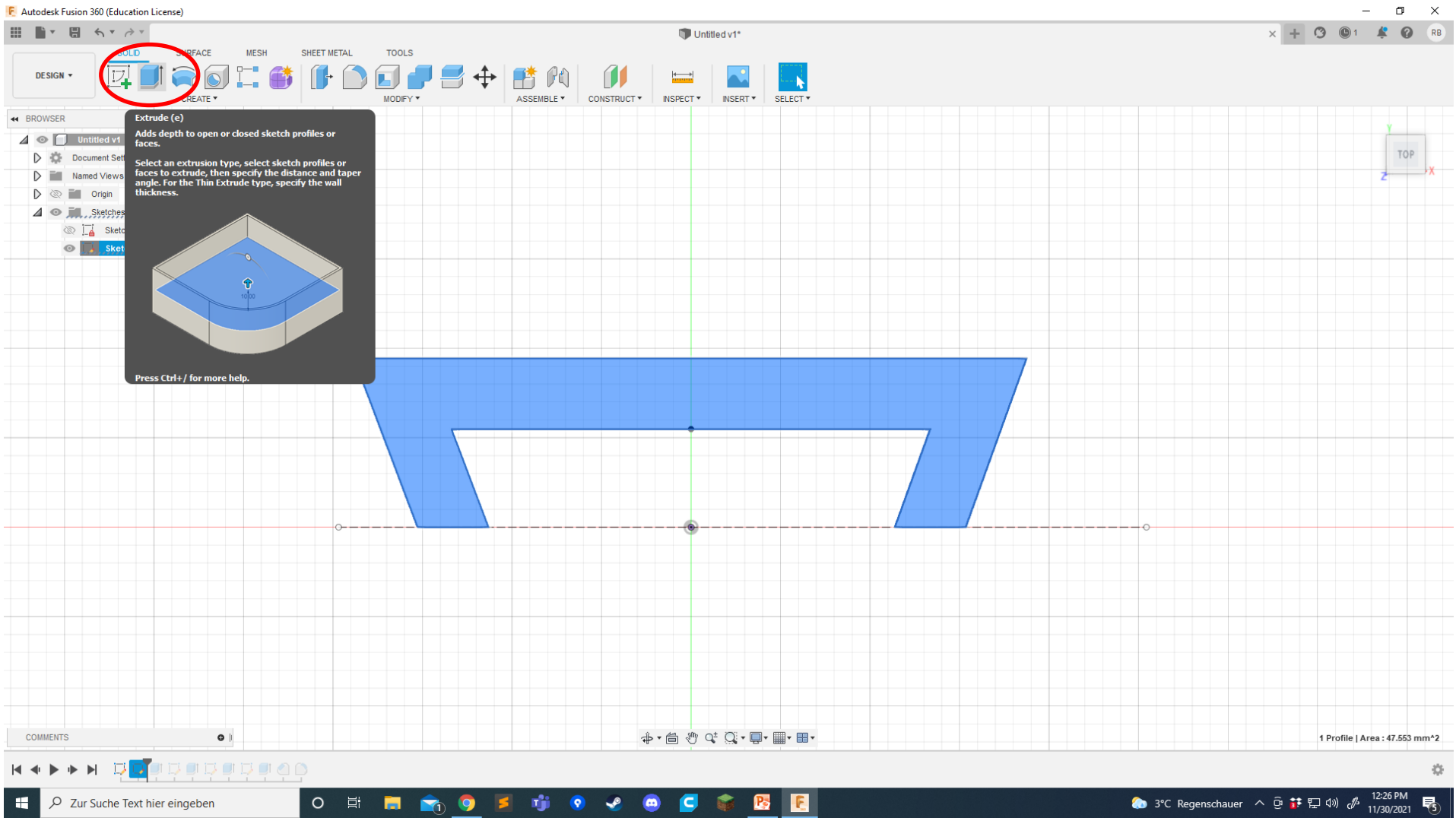

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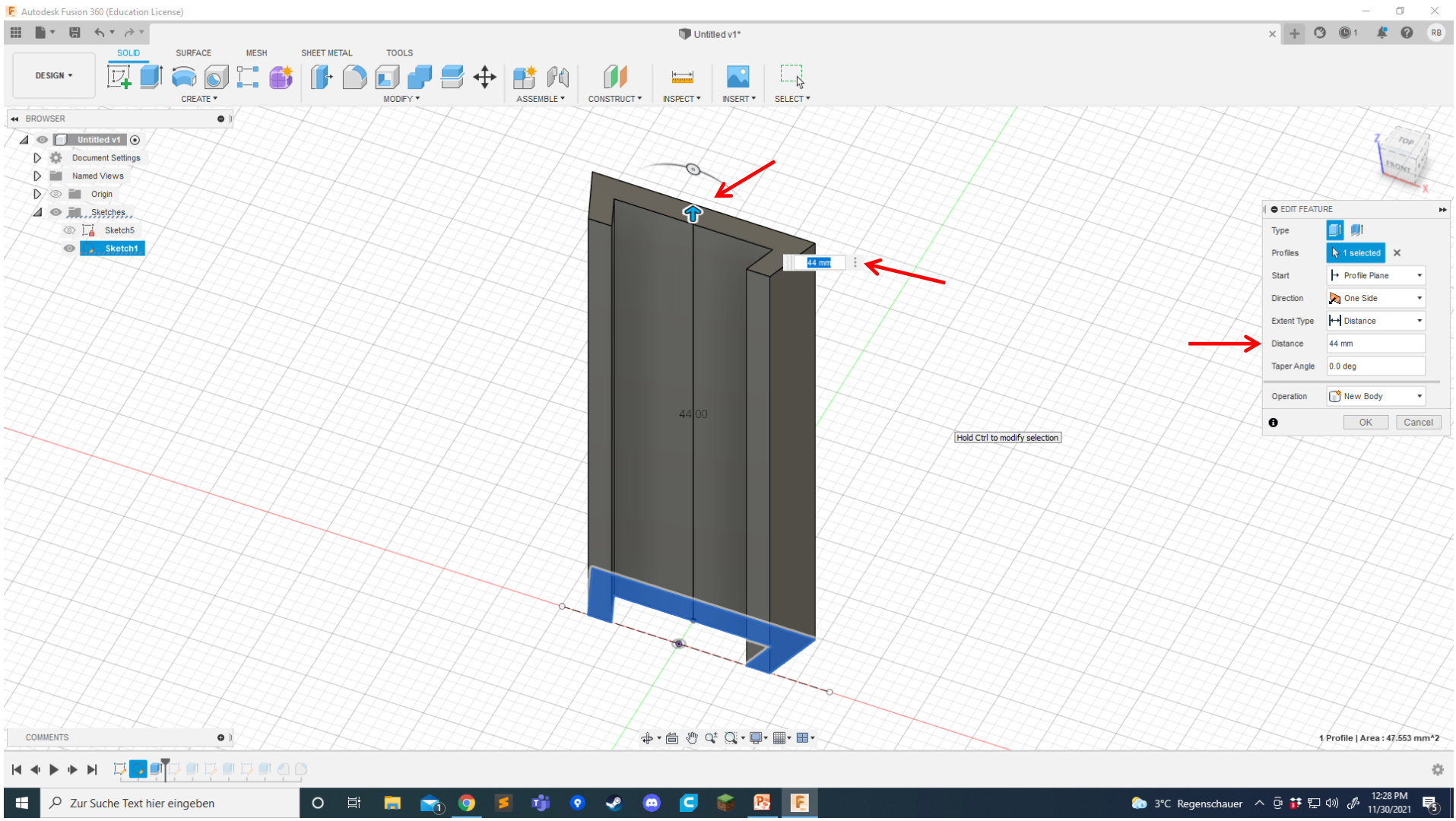

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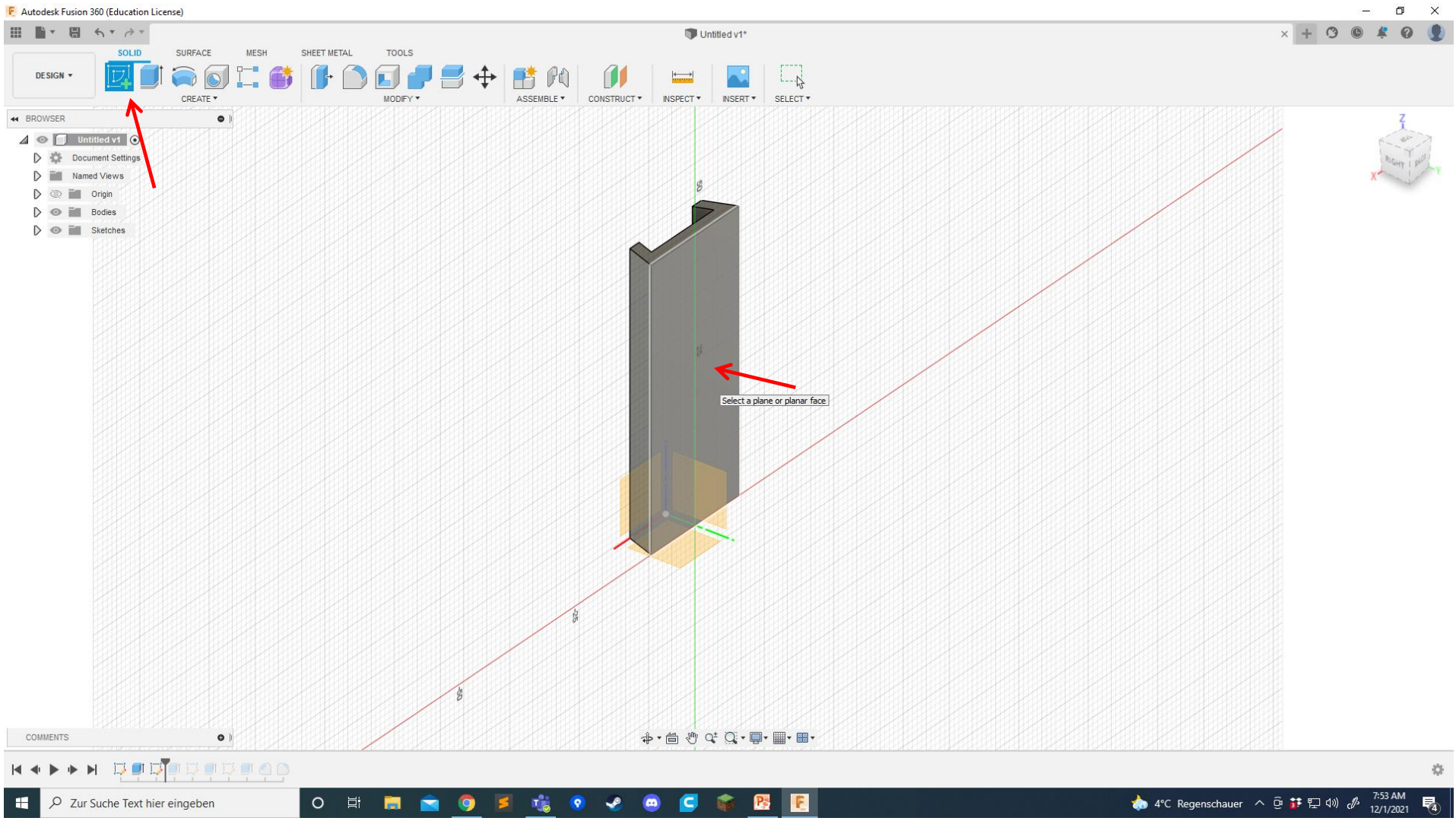

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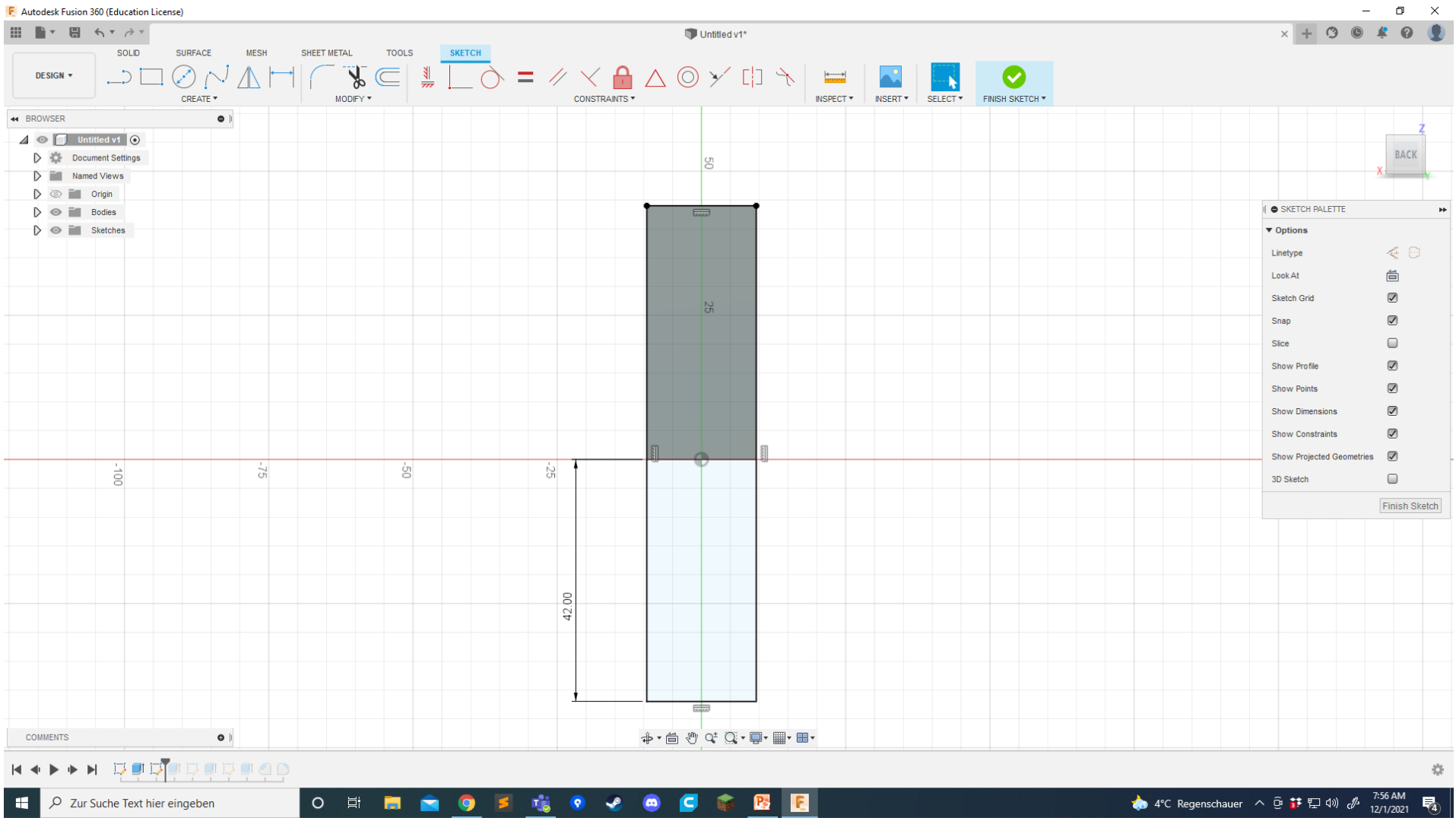

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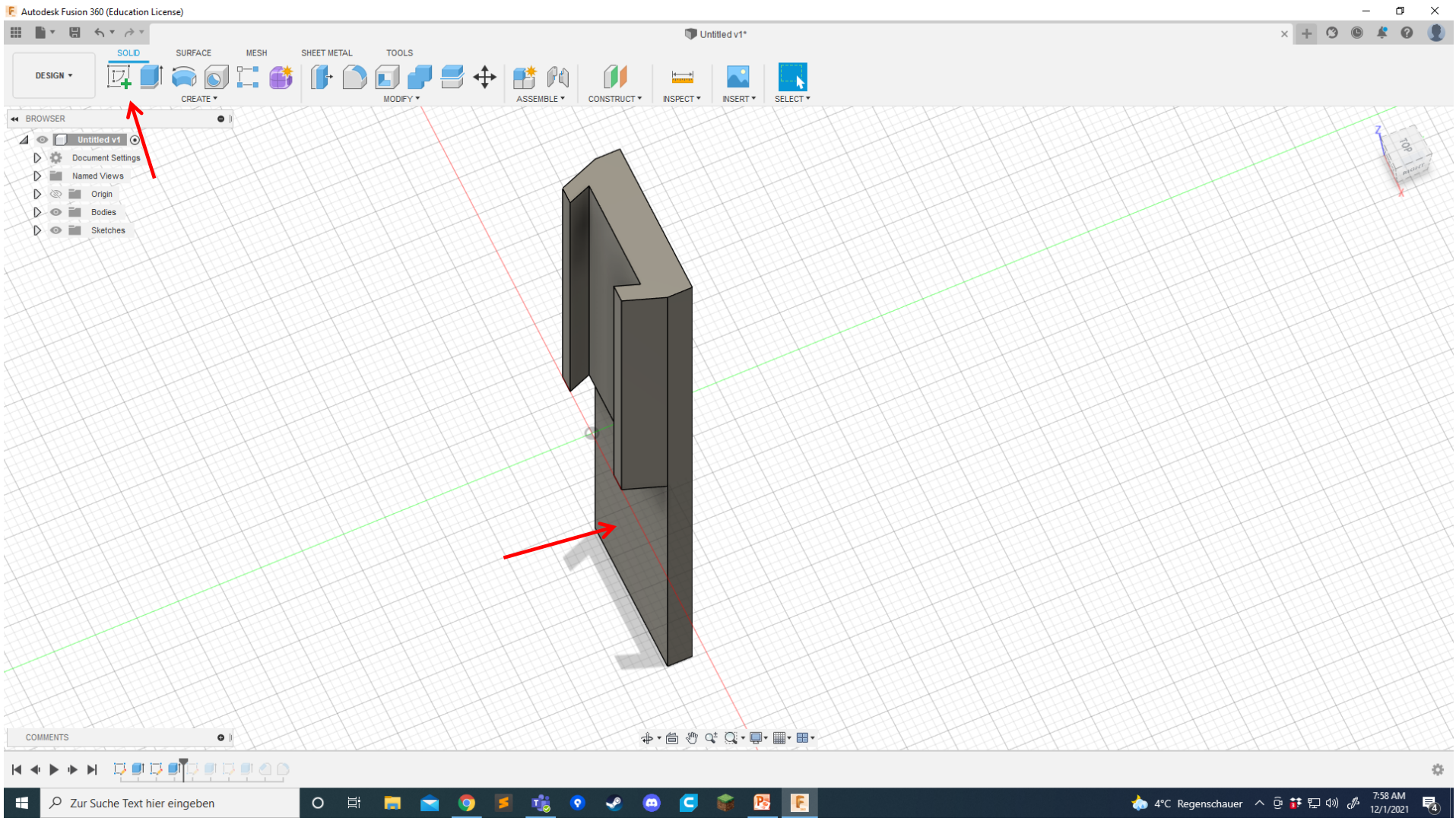

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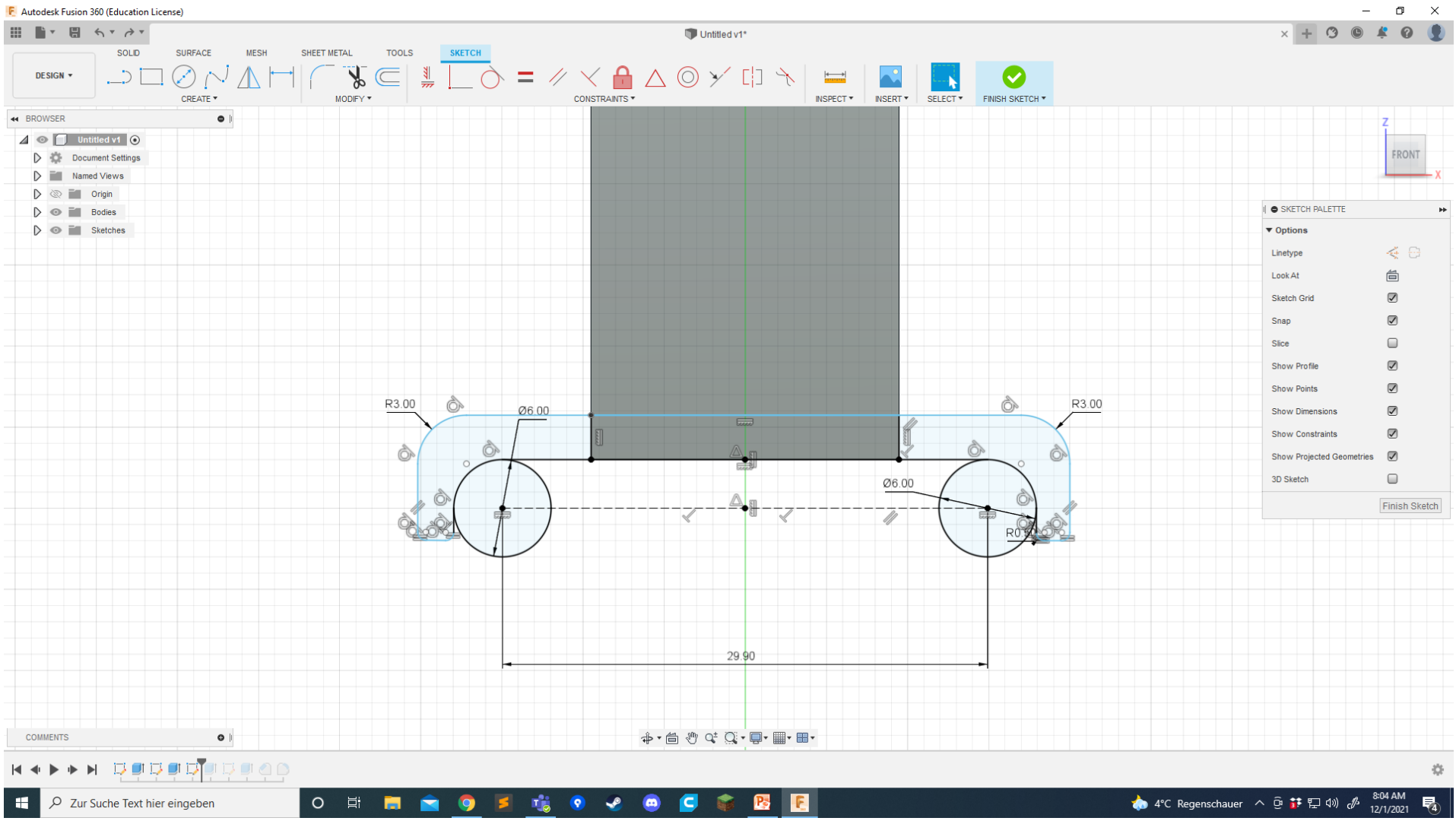

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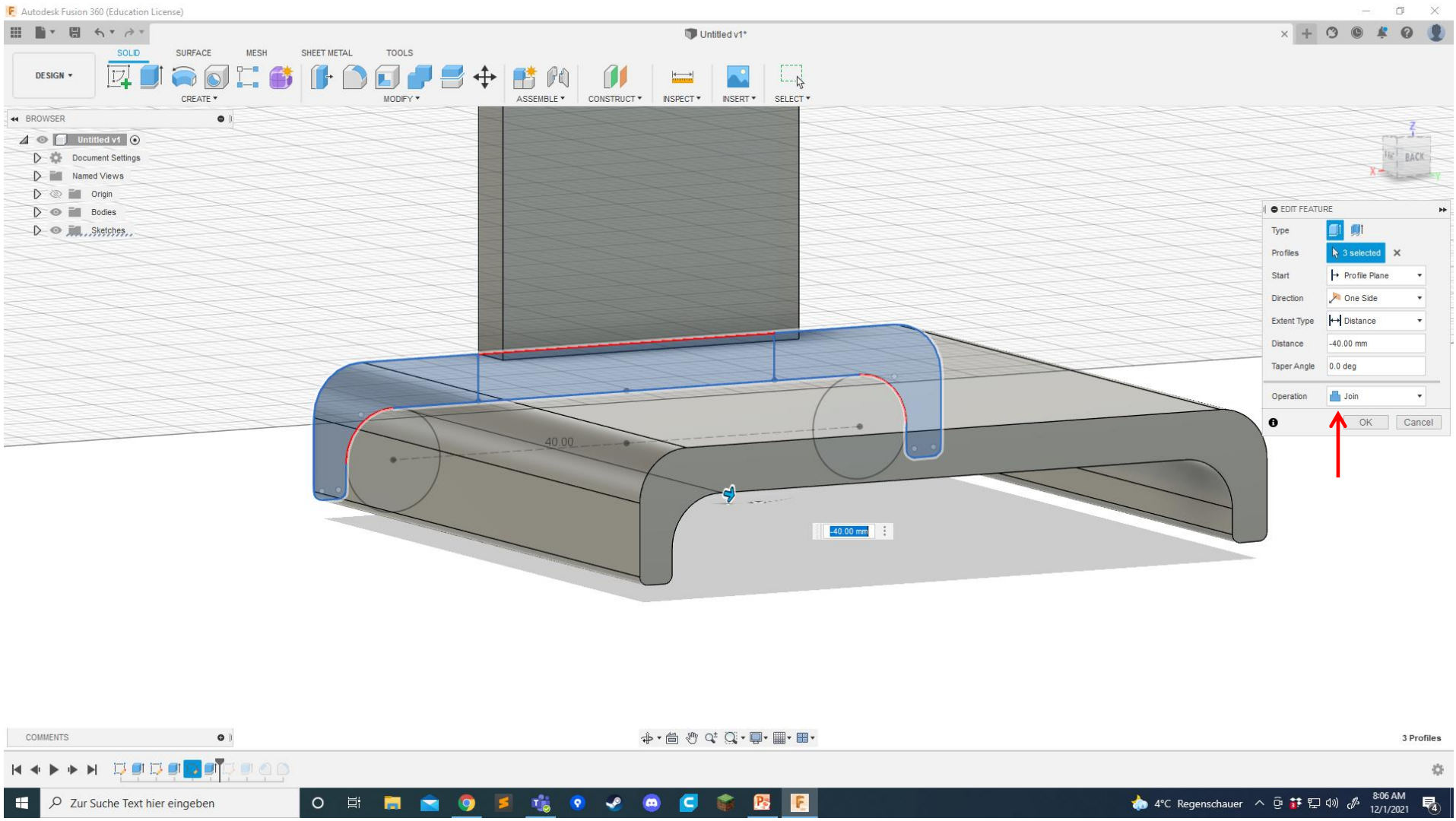

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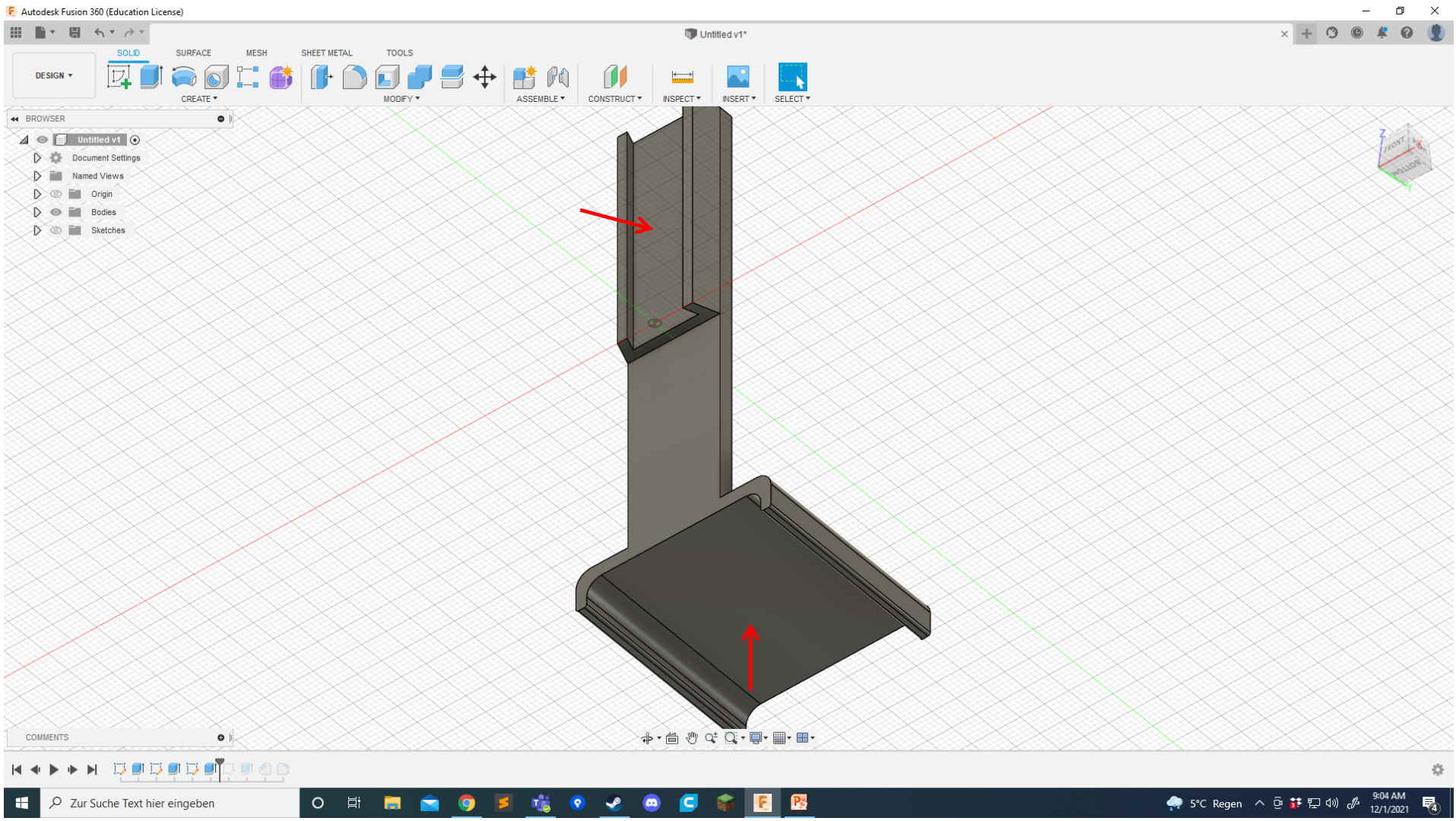

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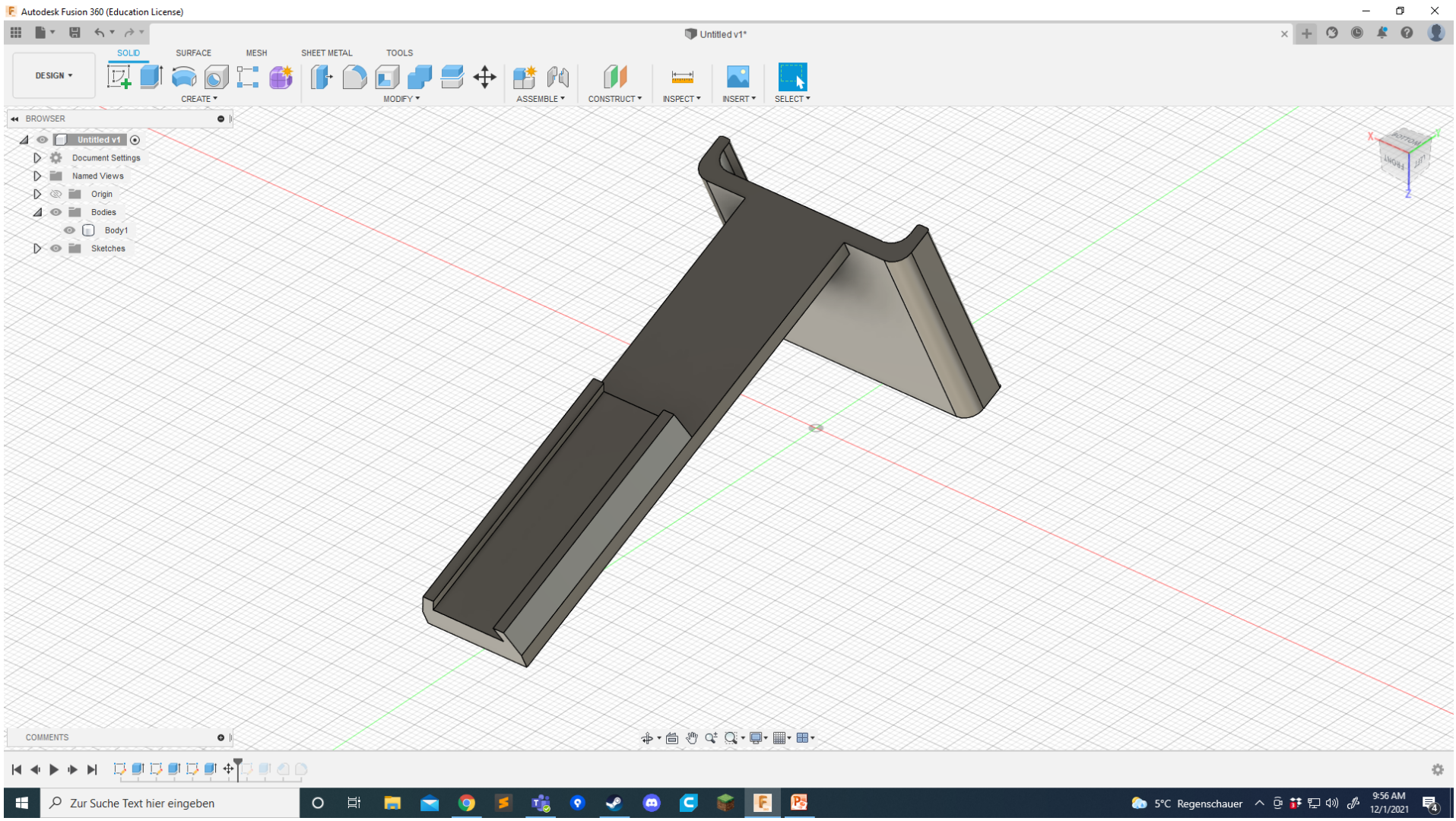

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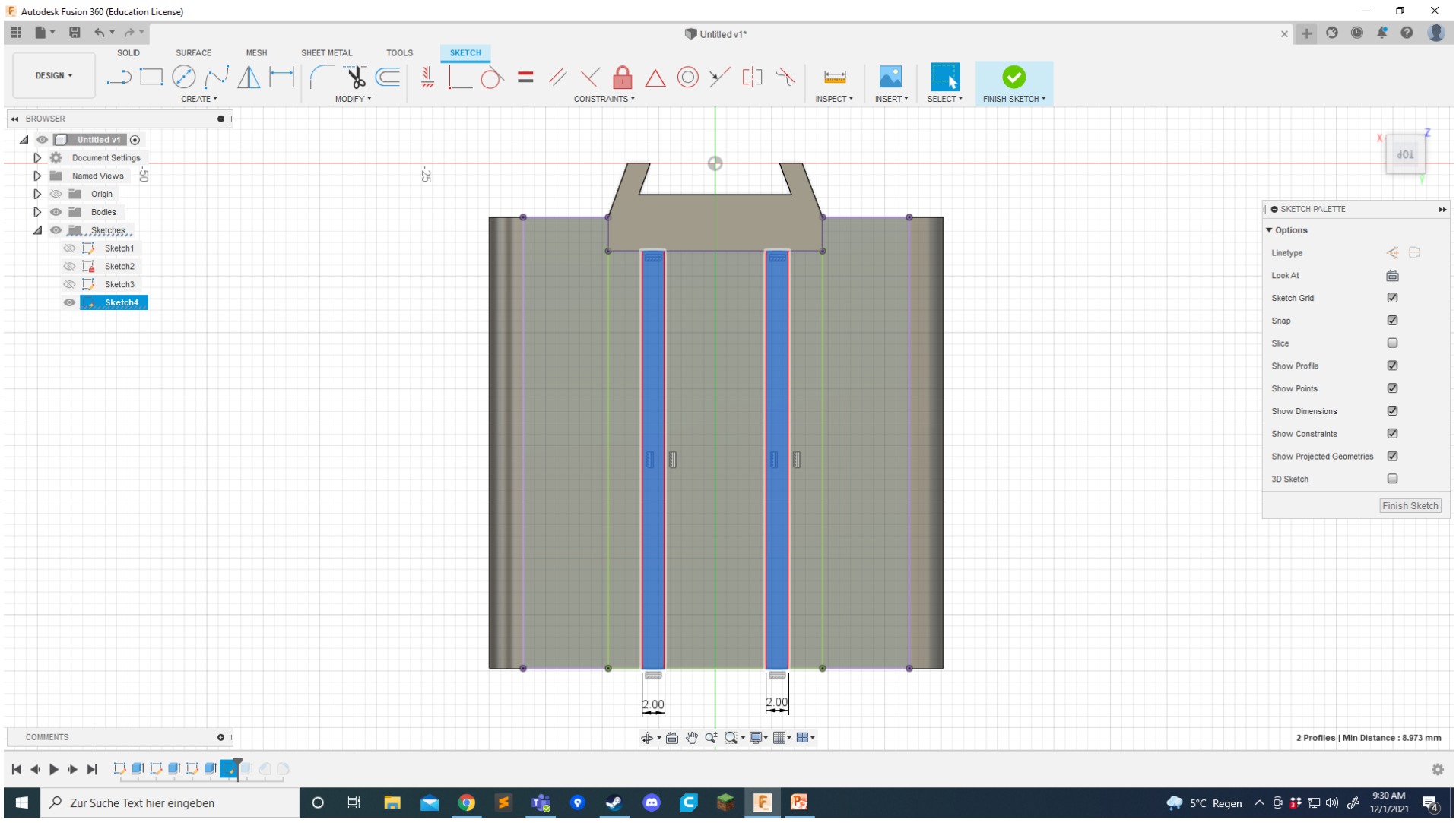

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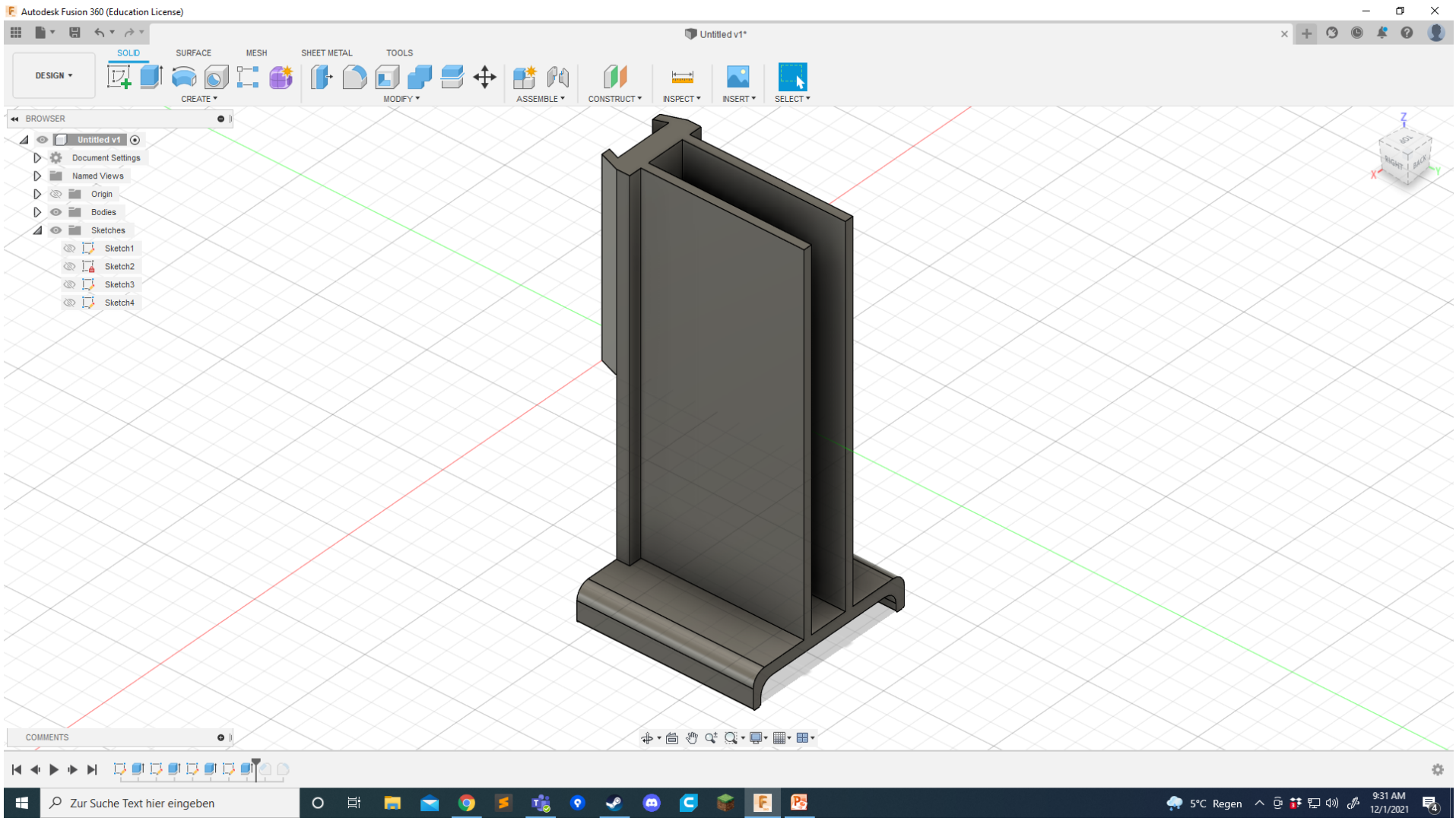
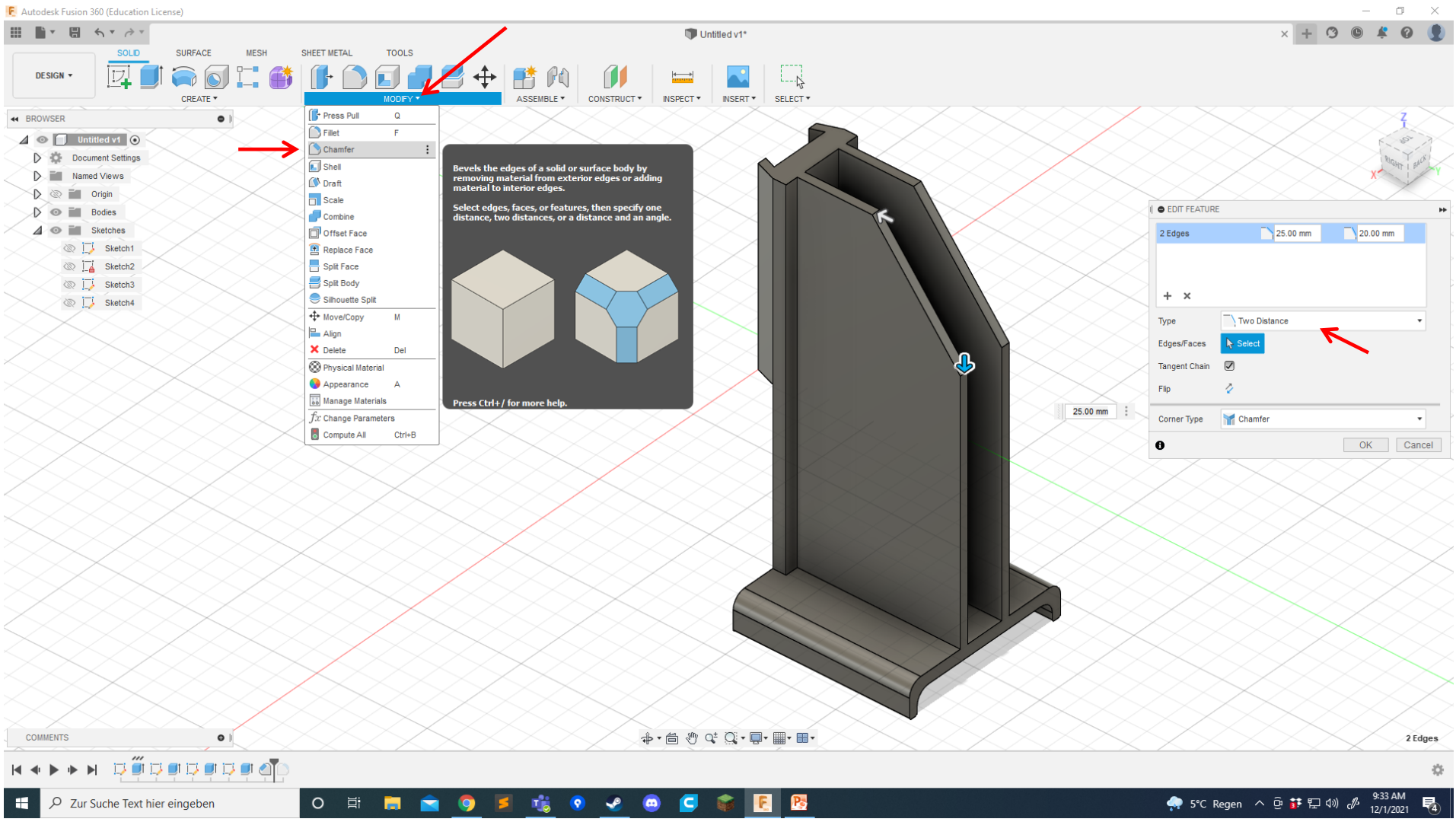
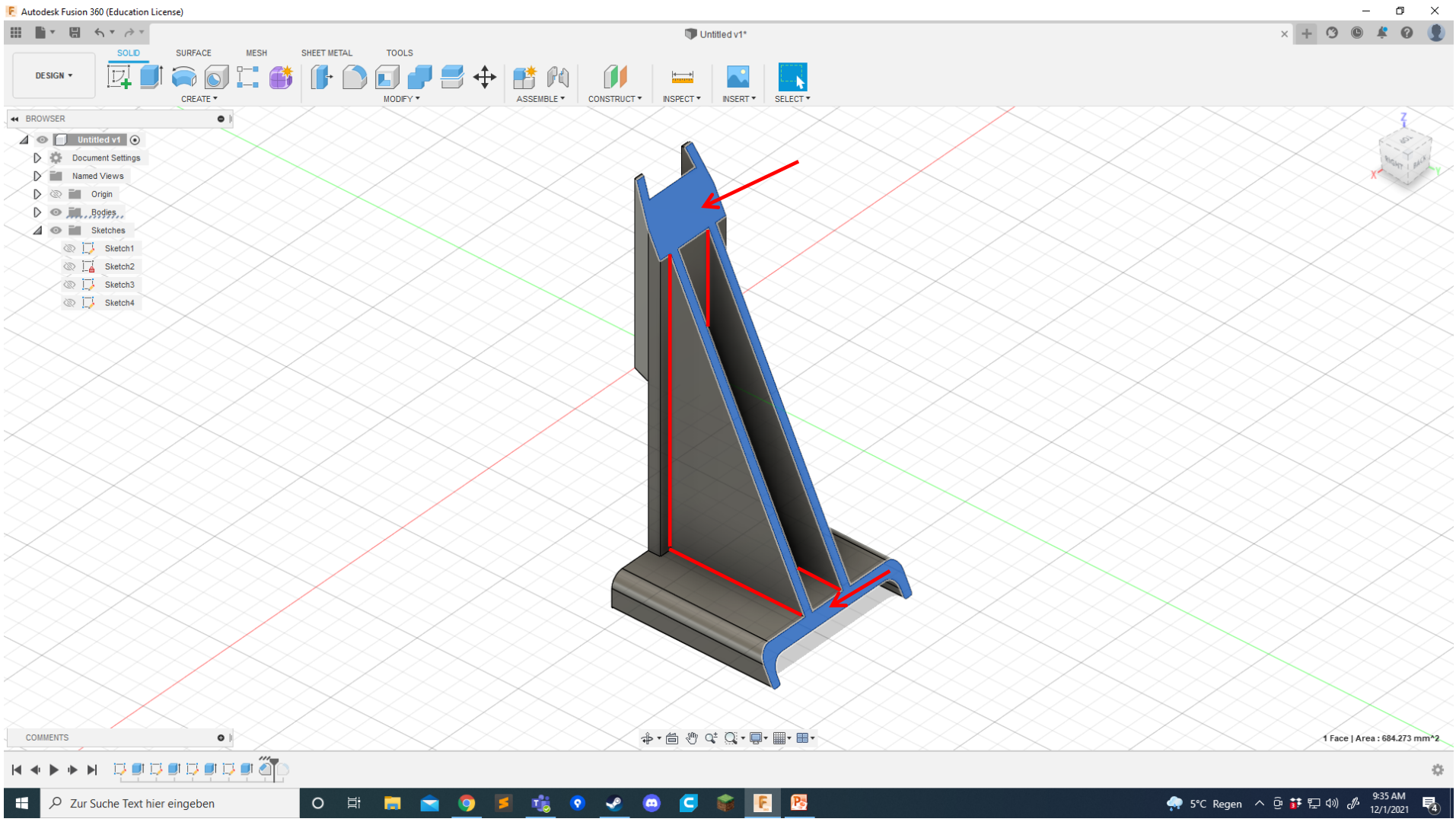


How to design 3D objects:The draft



How to design 3D objects:The draft



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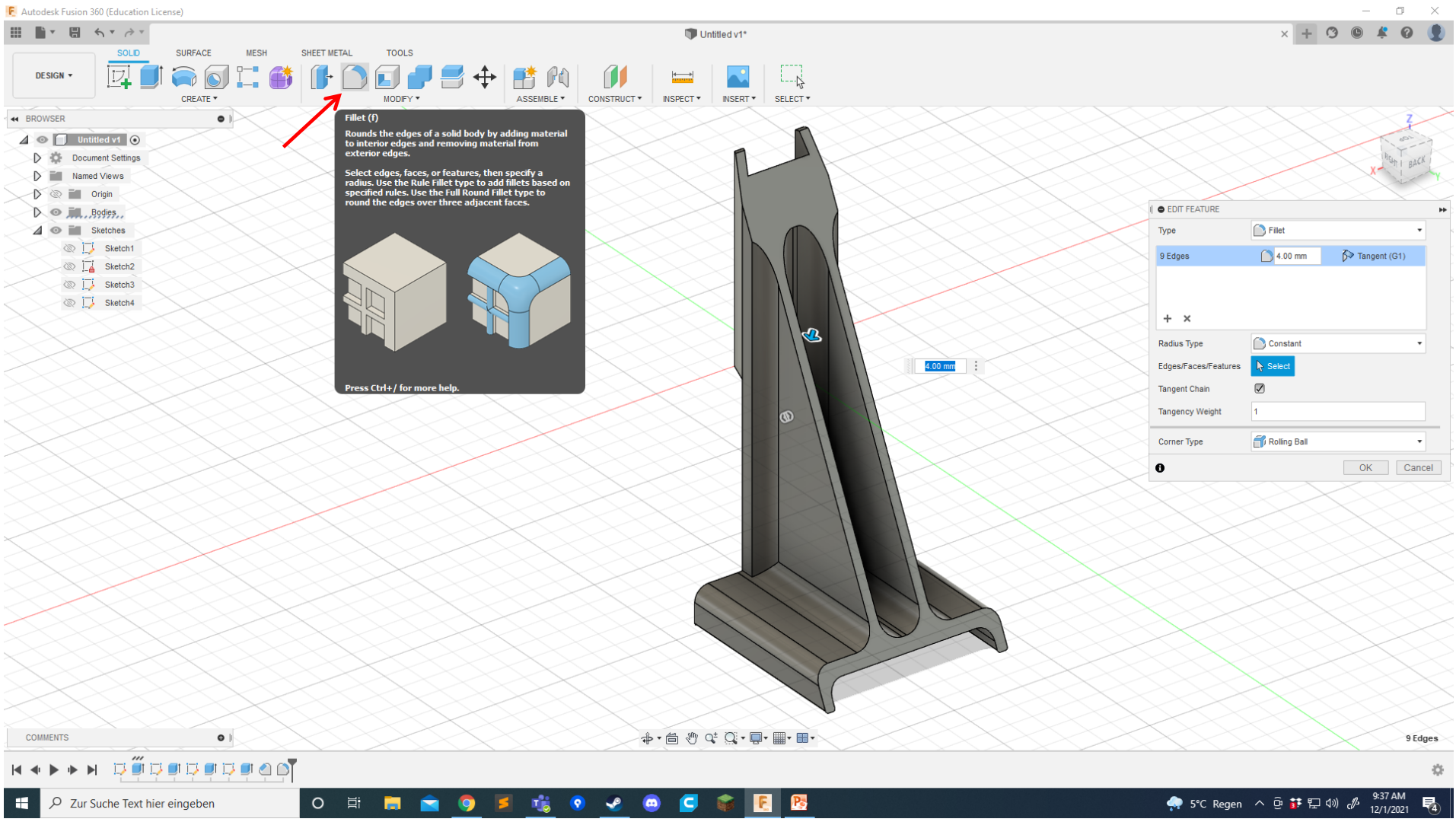
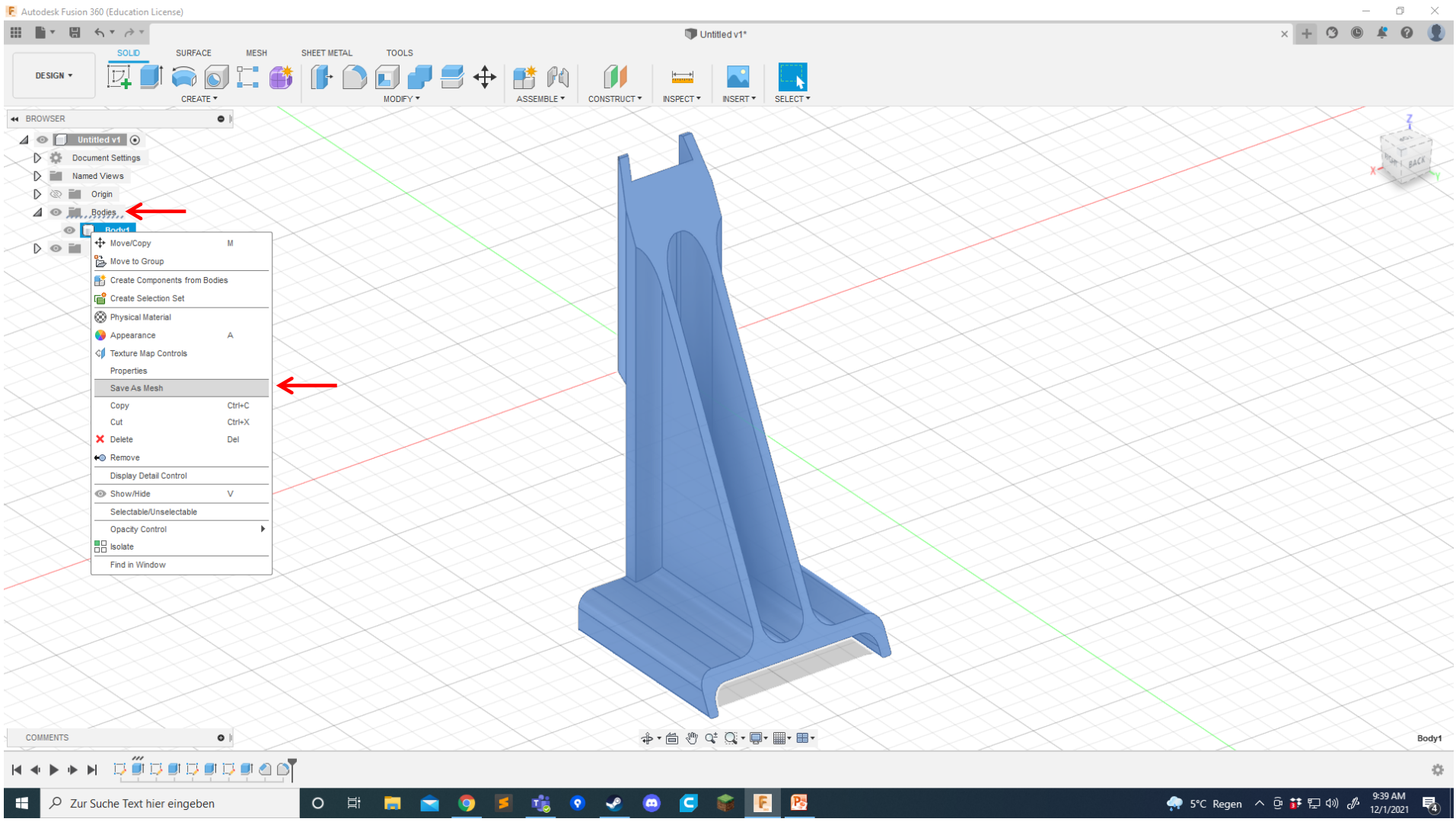
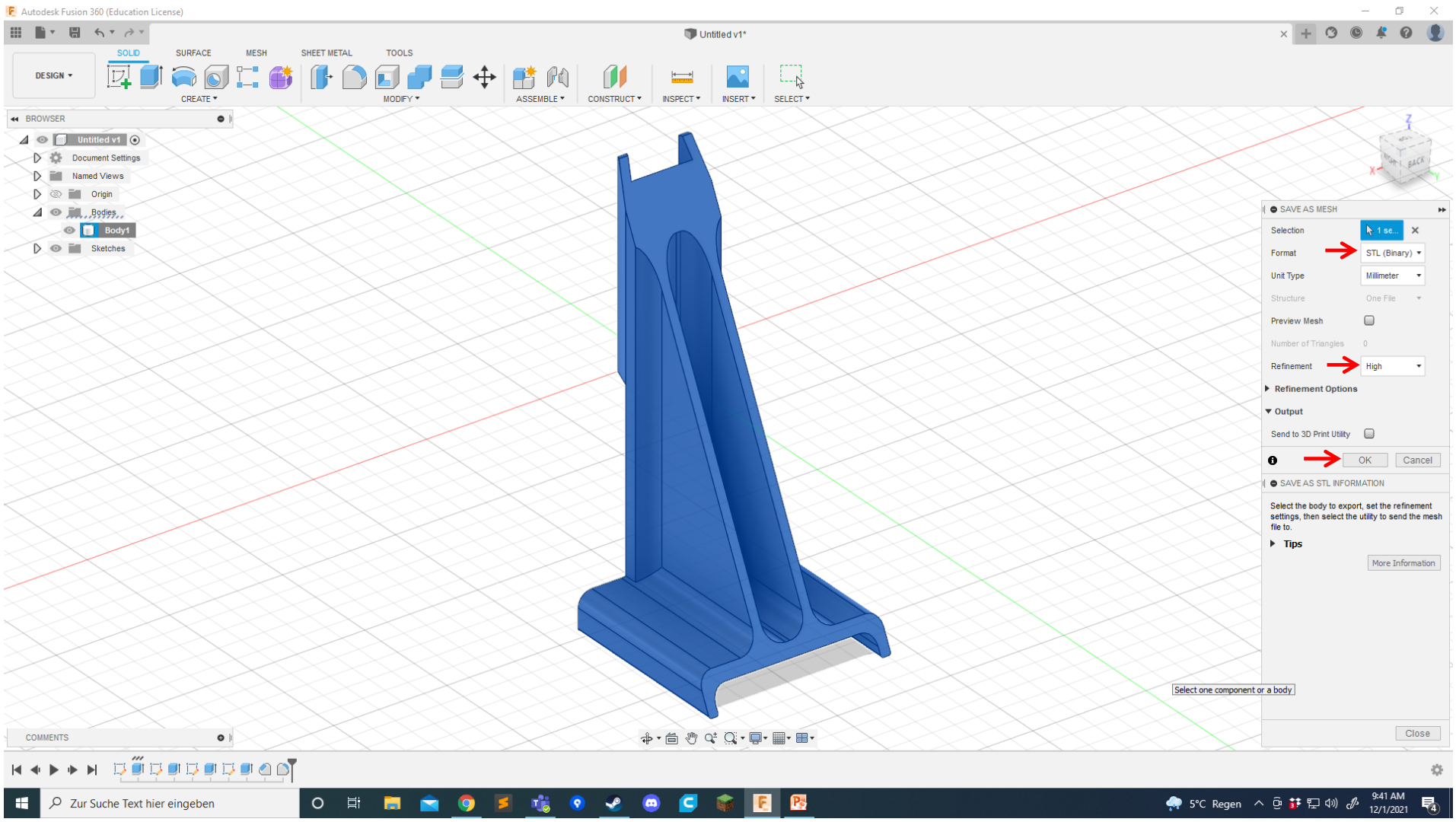


How to design 3D objects:The draft

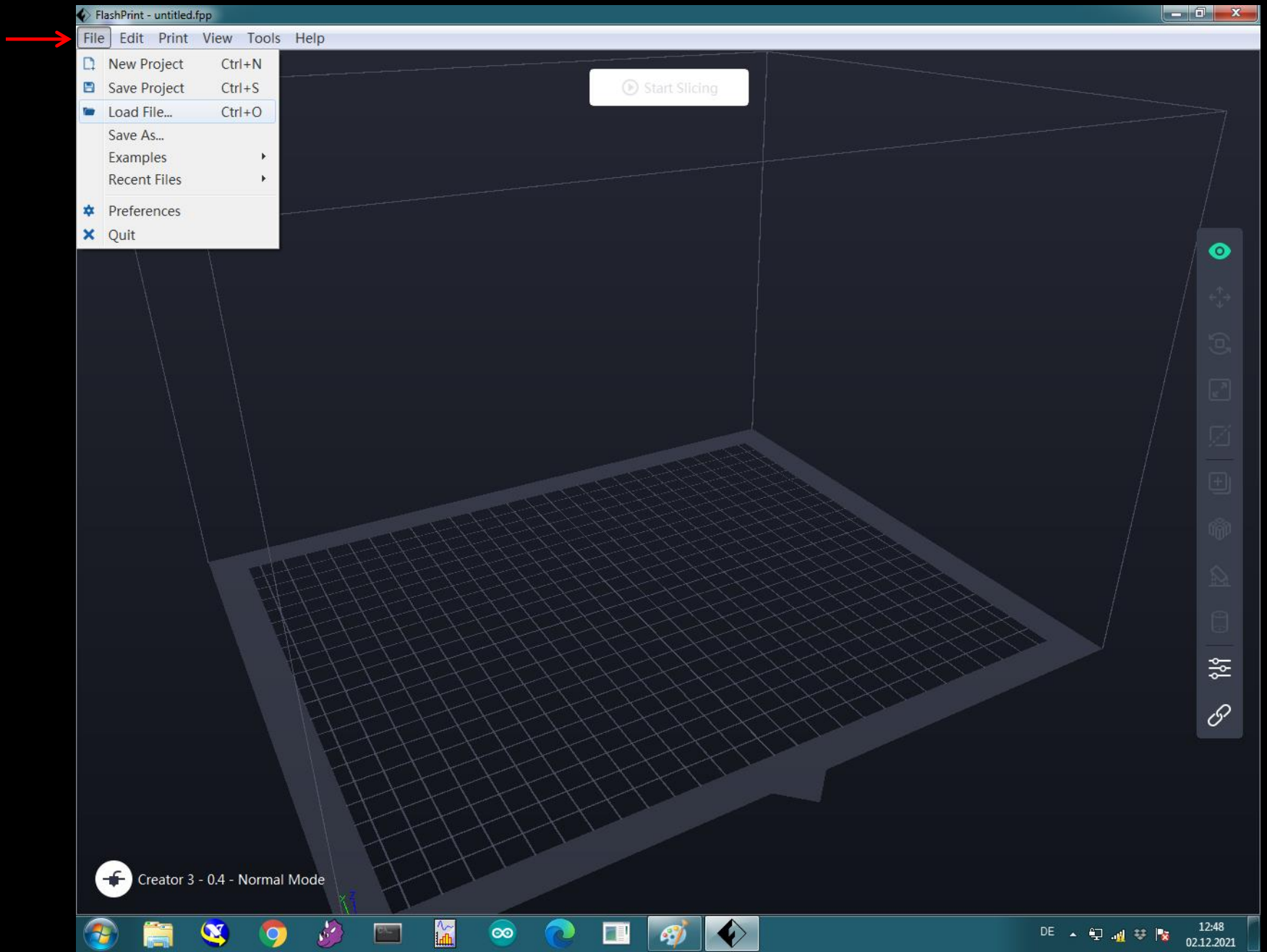


How to design 3D objects:The draft

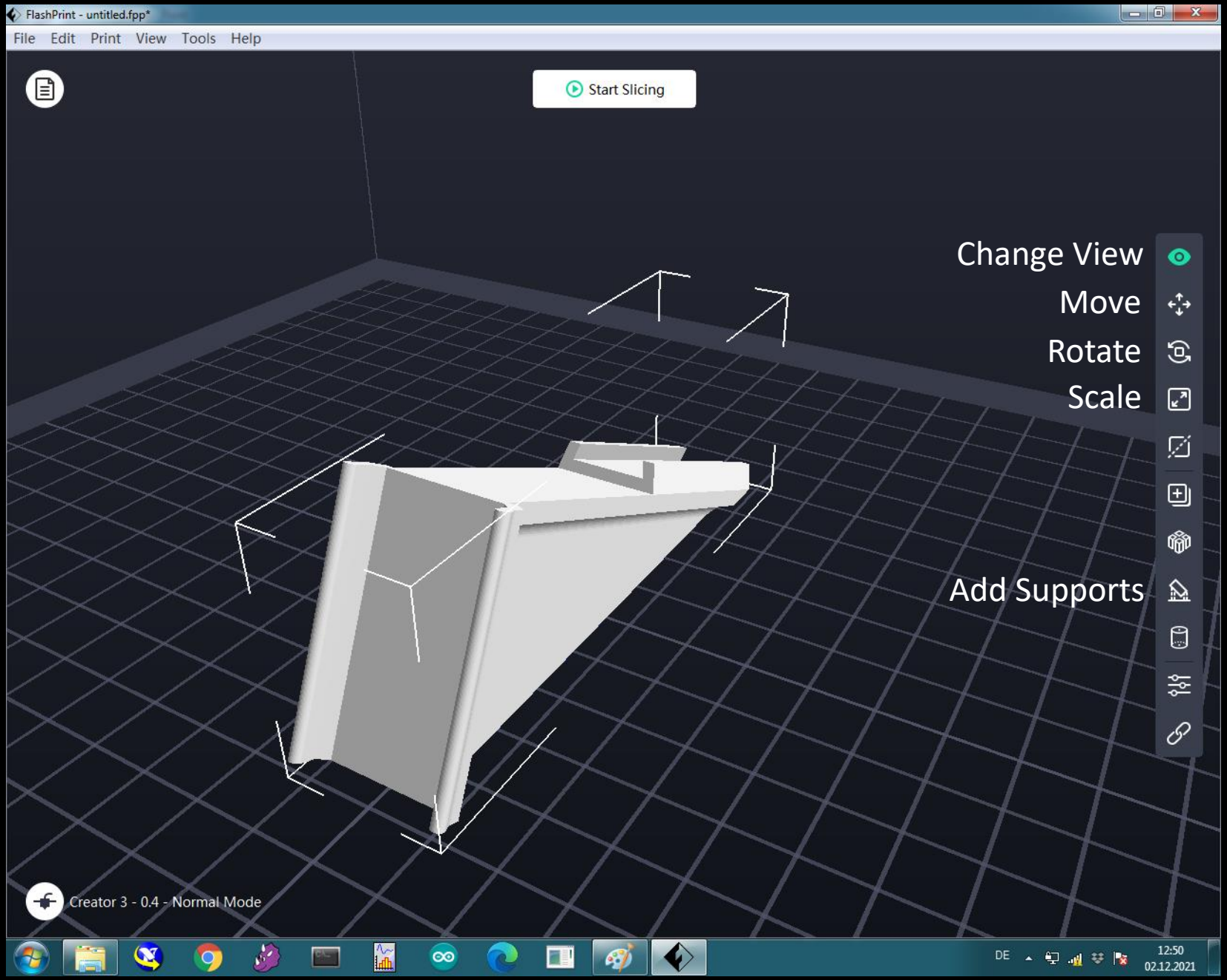


How to print with the Flashforge Creator 3

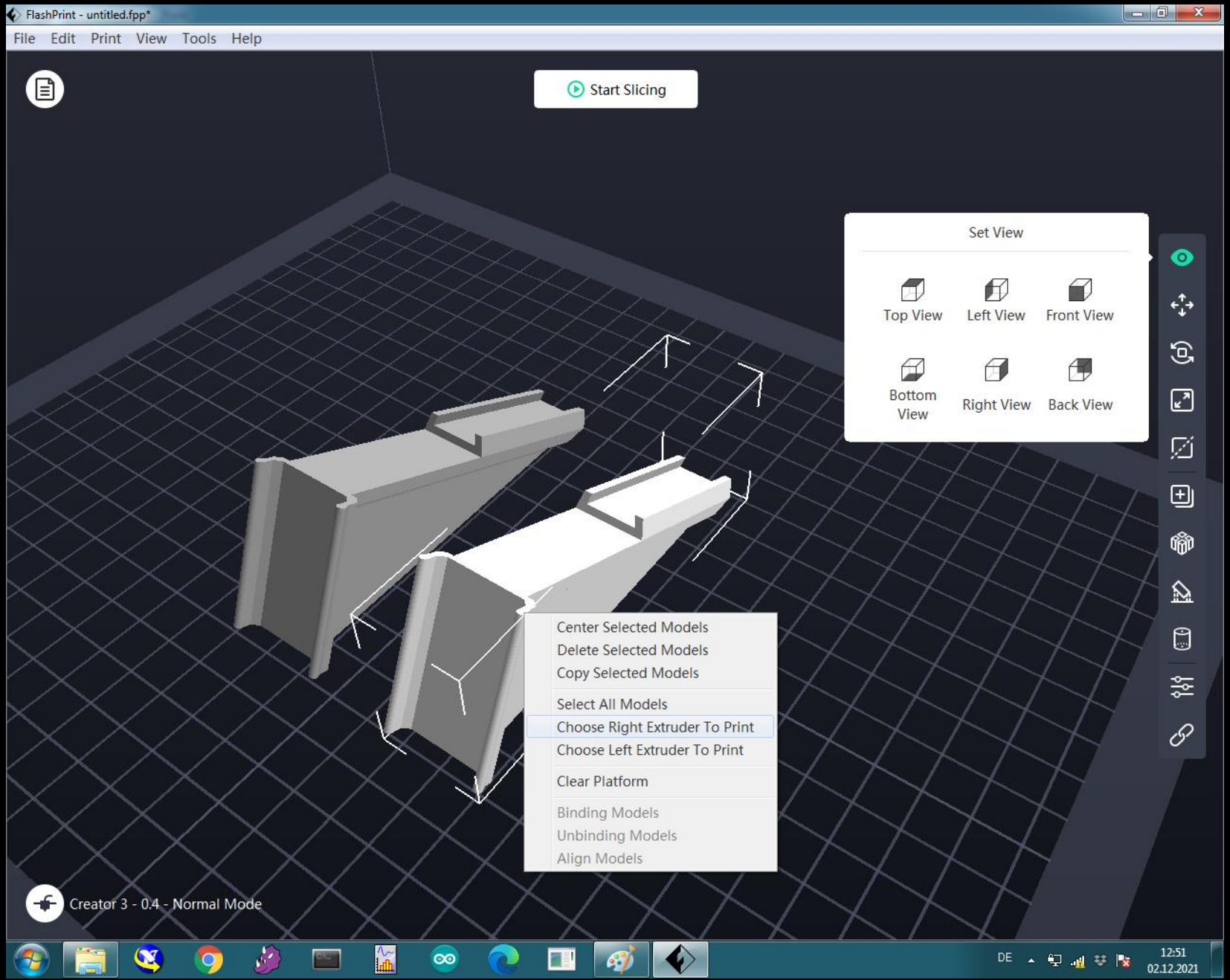
How to print: Flashforge



How to print: Flashforge



How to print: Flashforge



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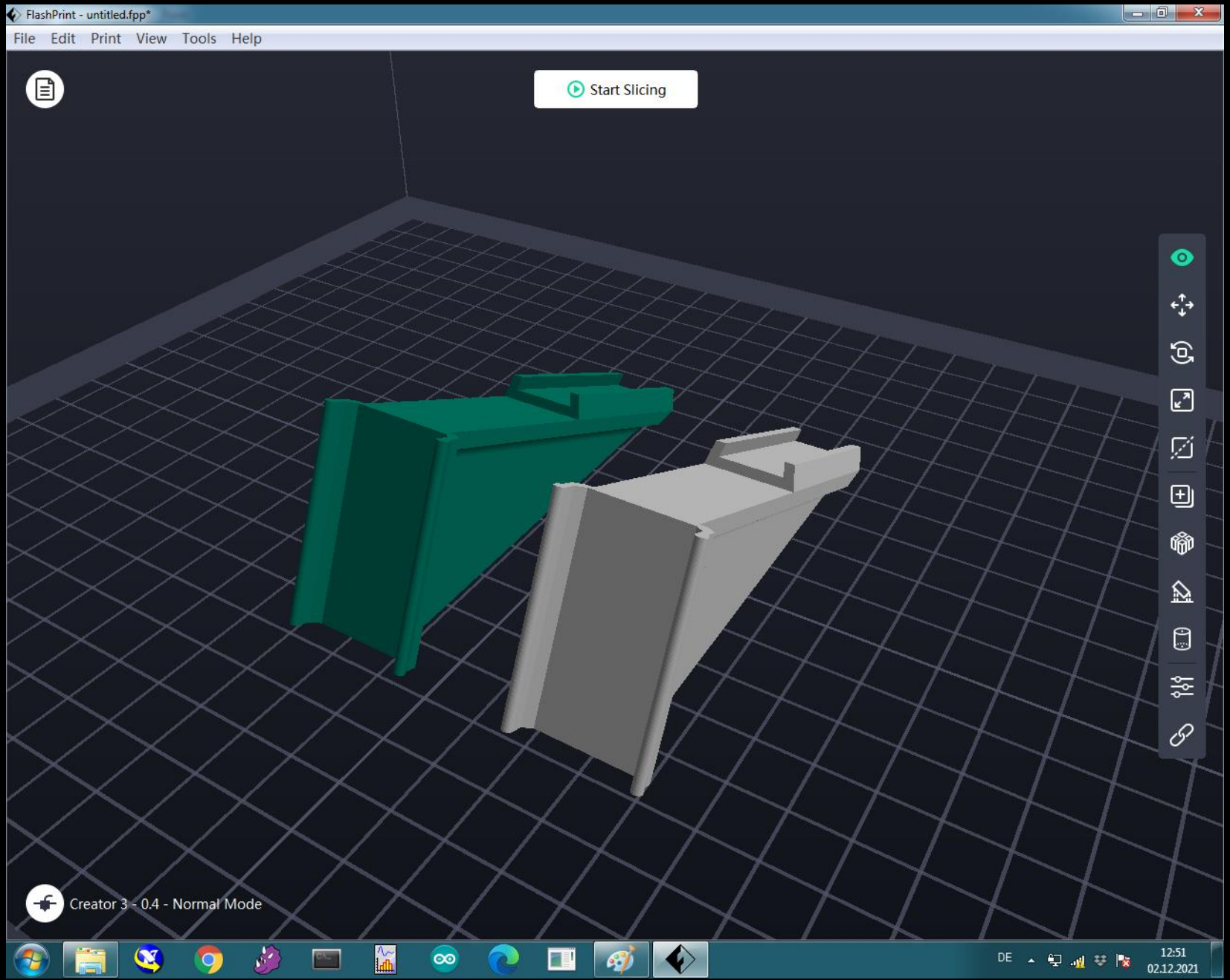

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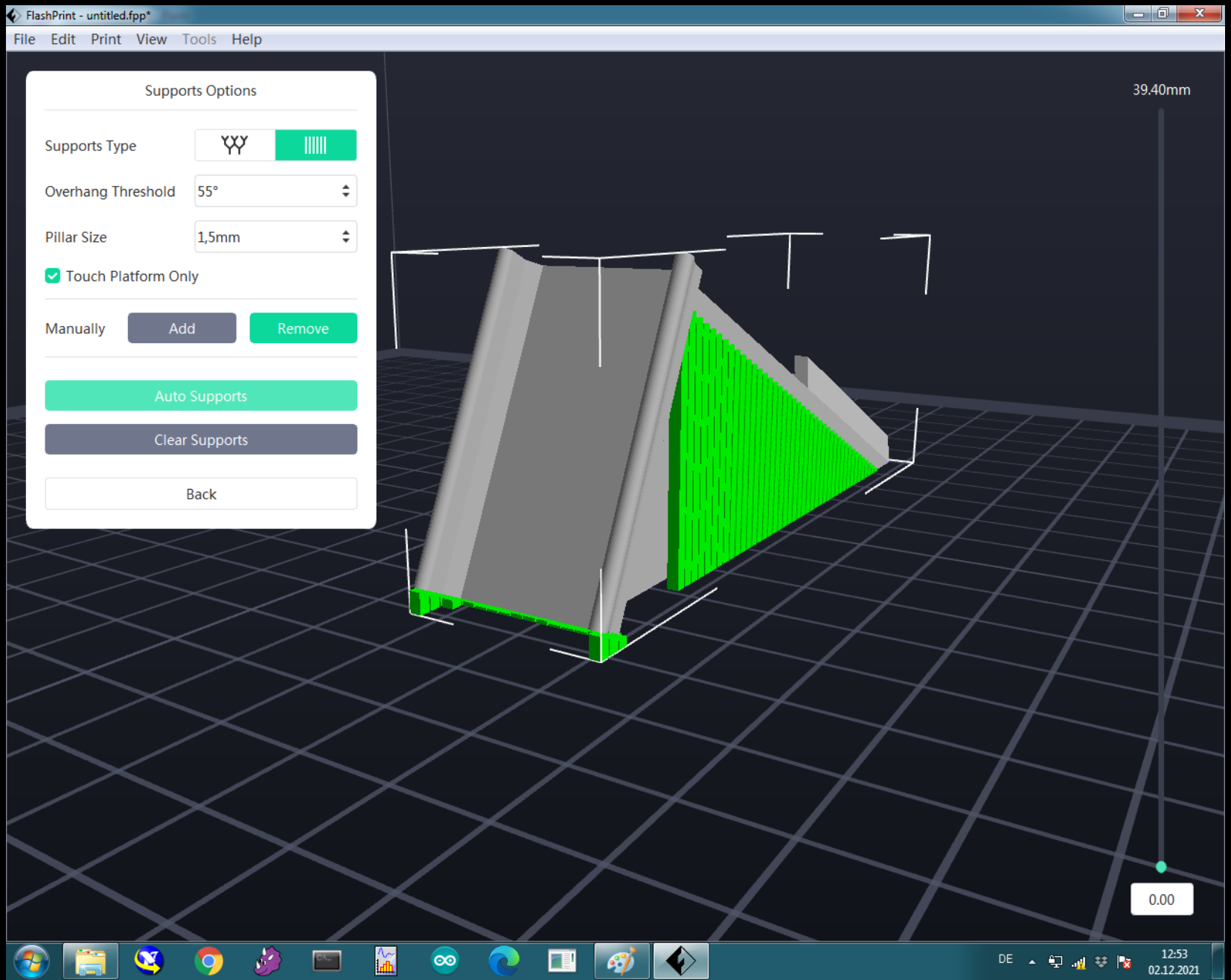

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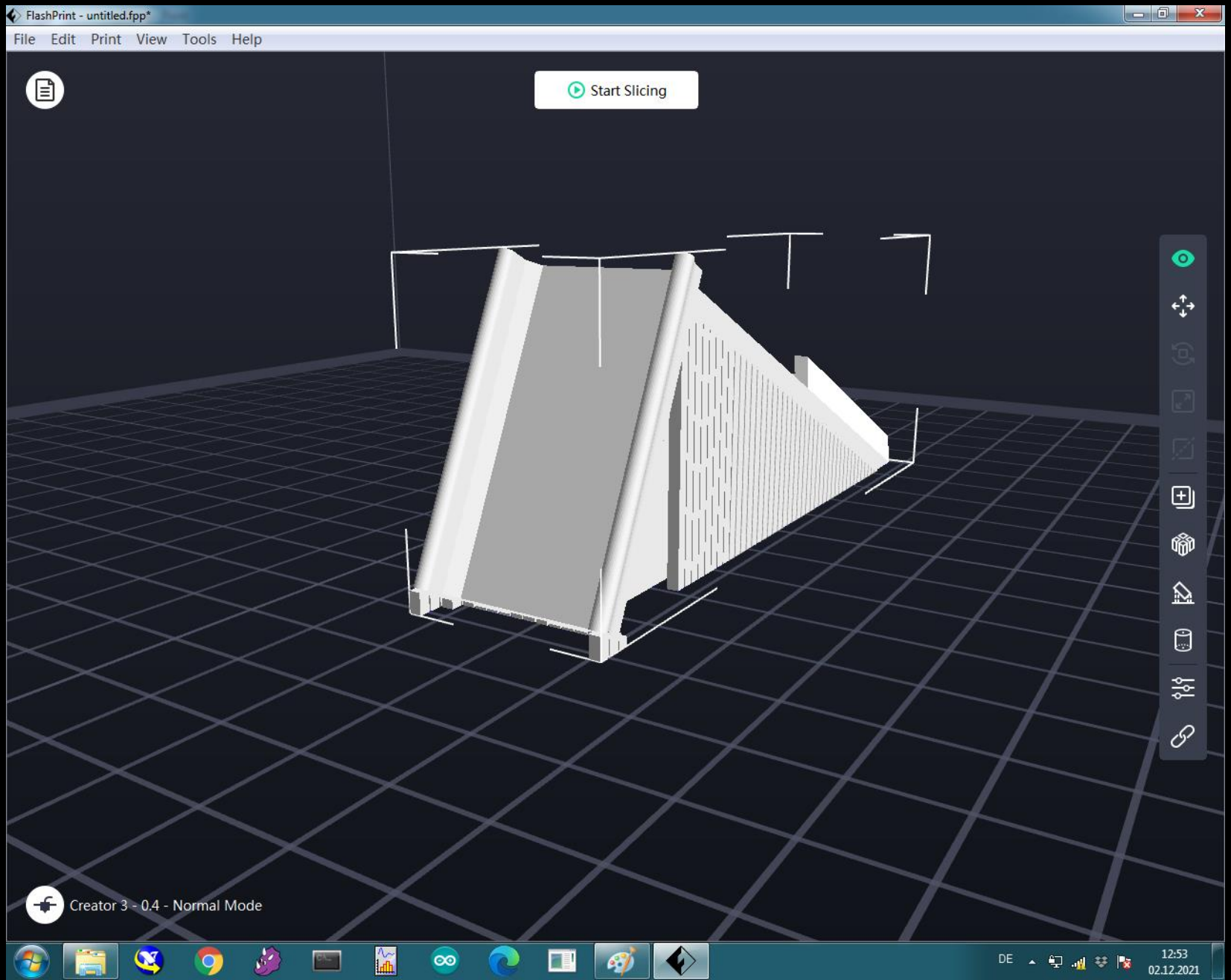

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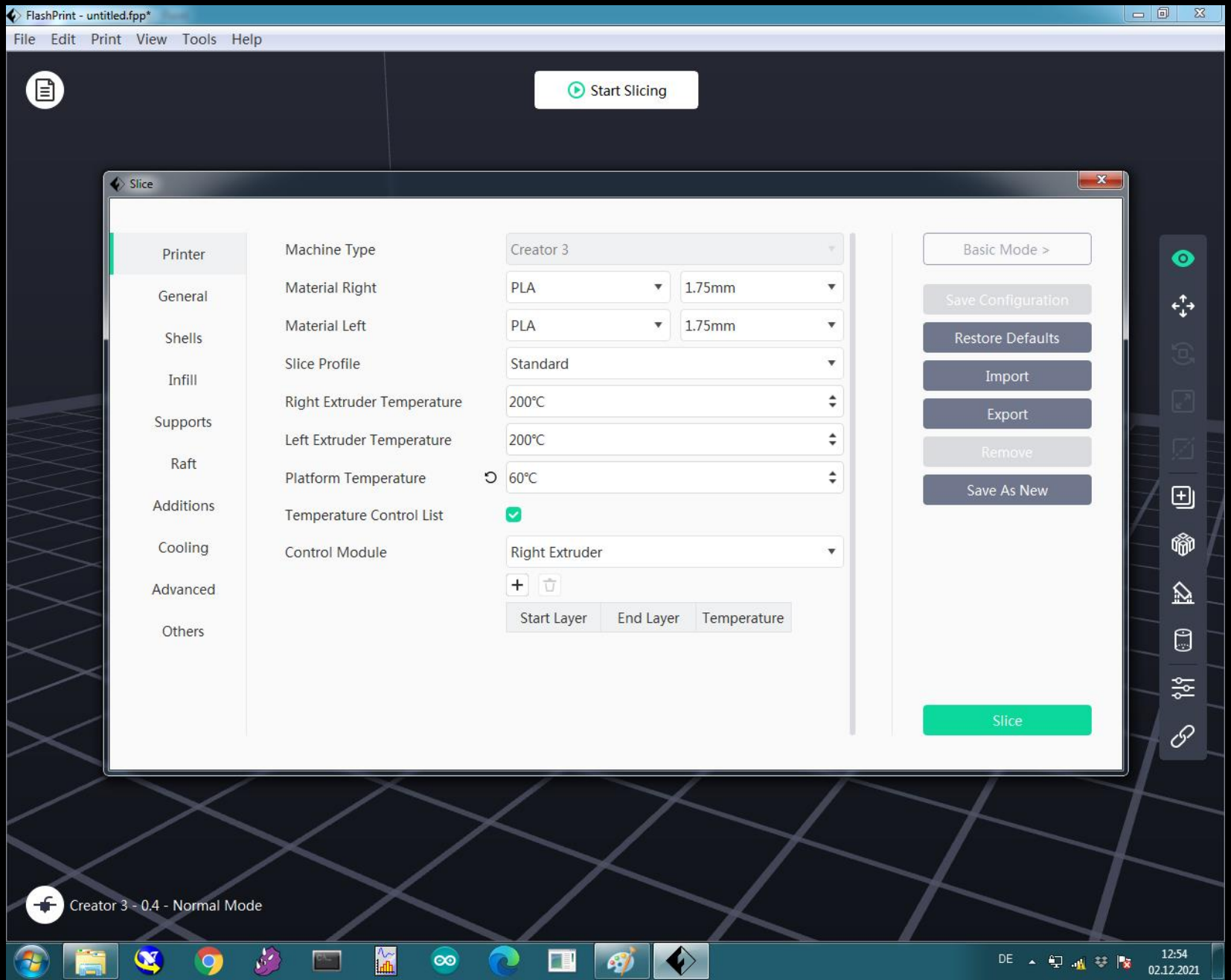

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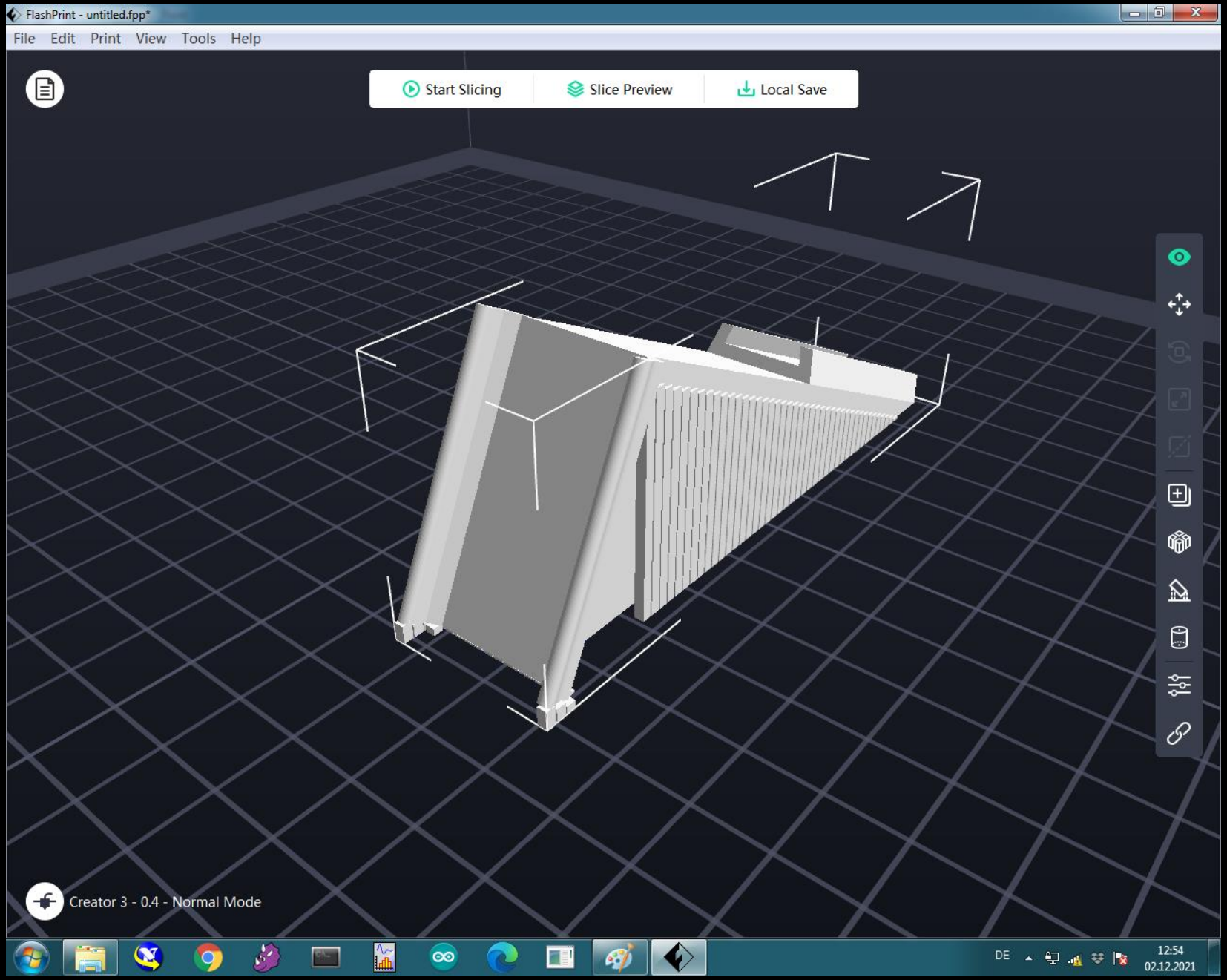

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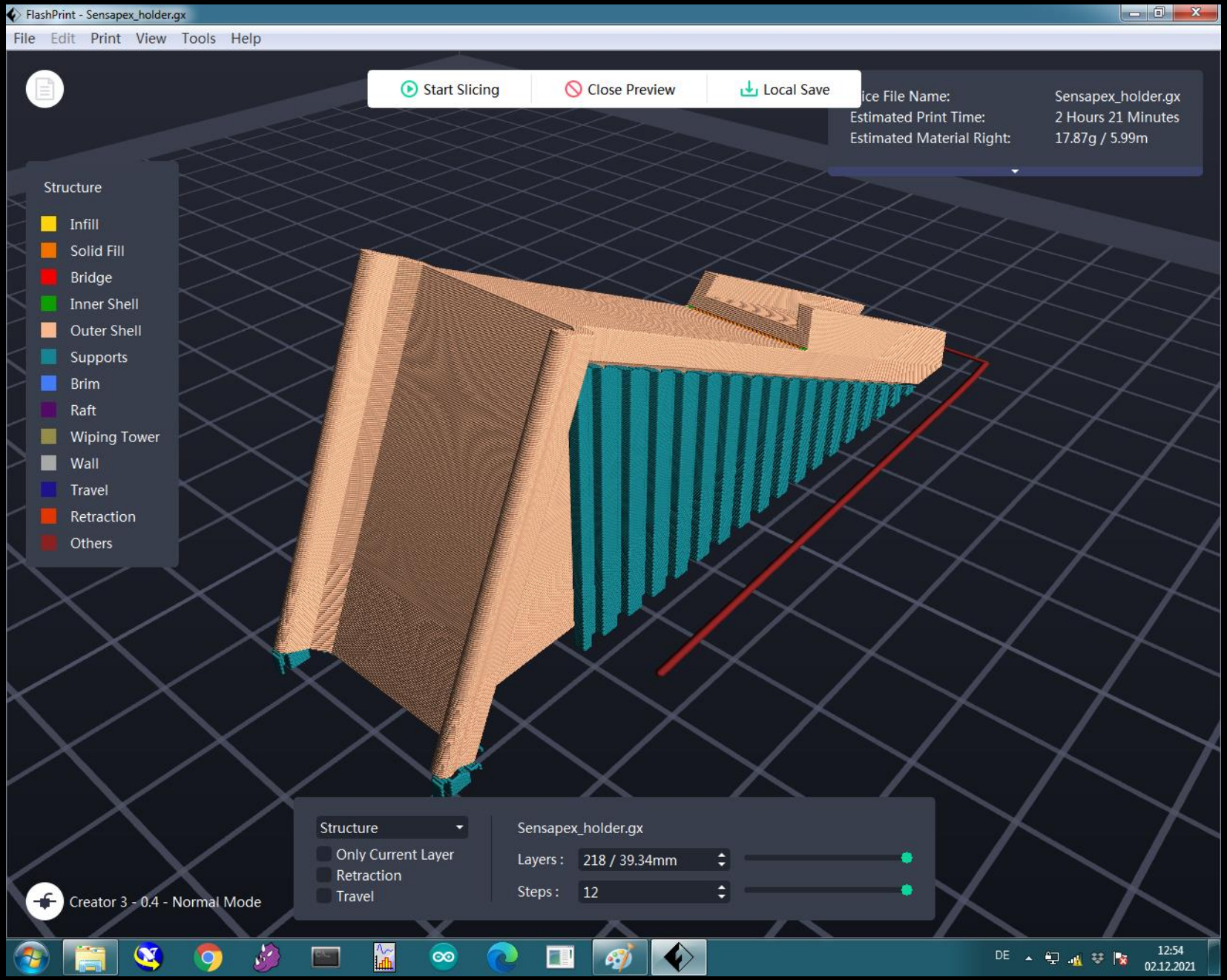

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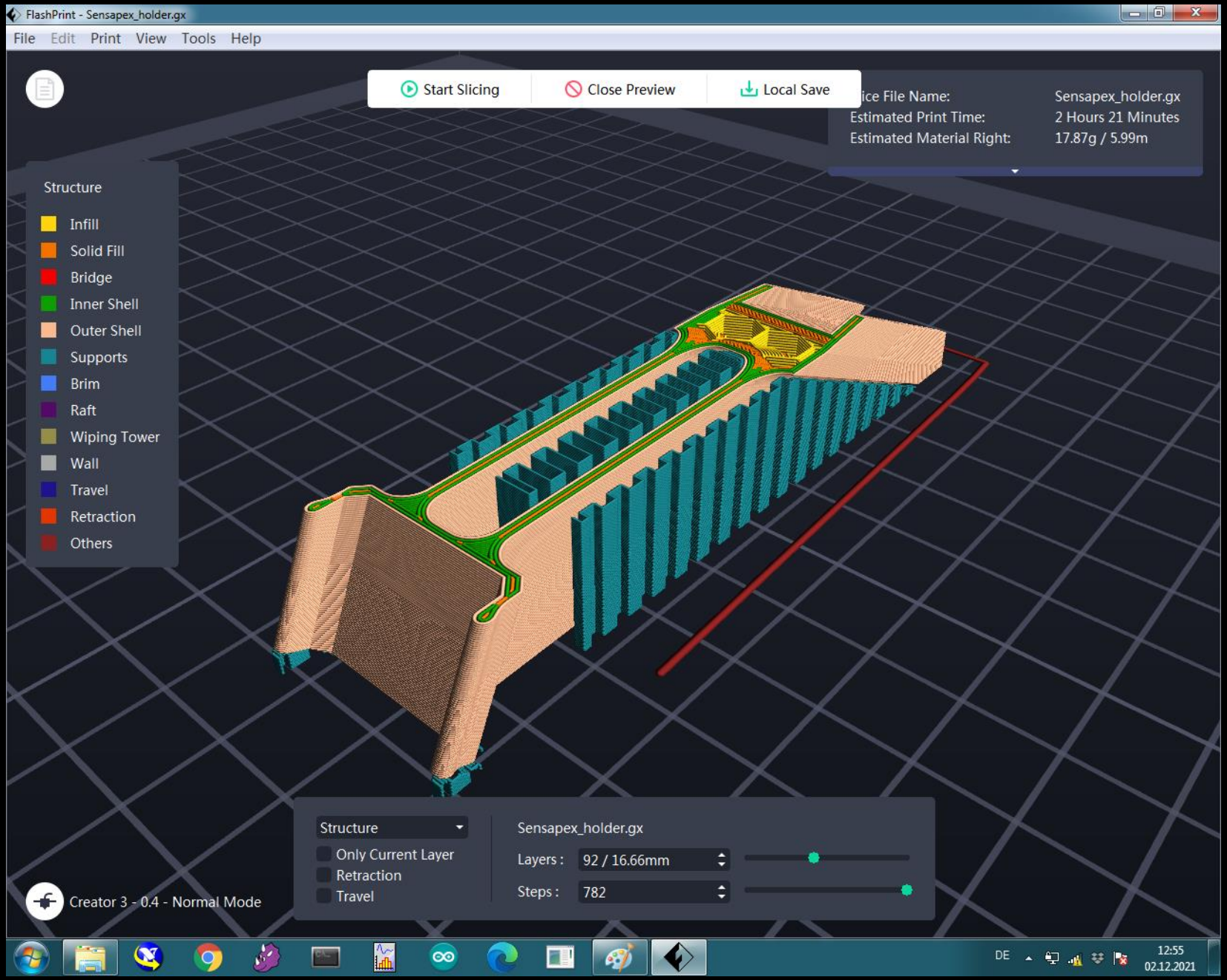

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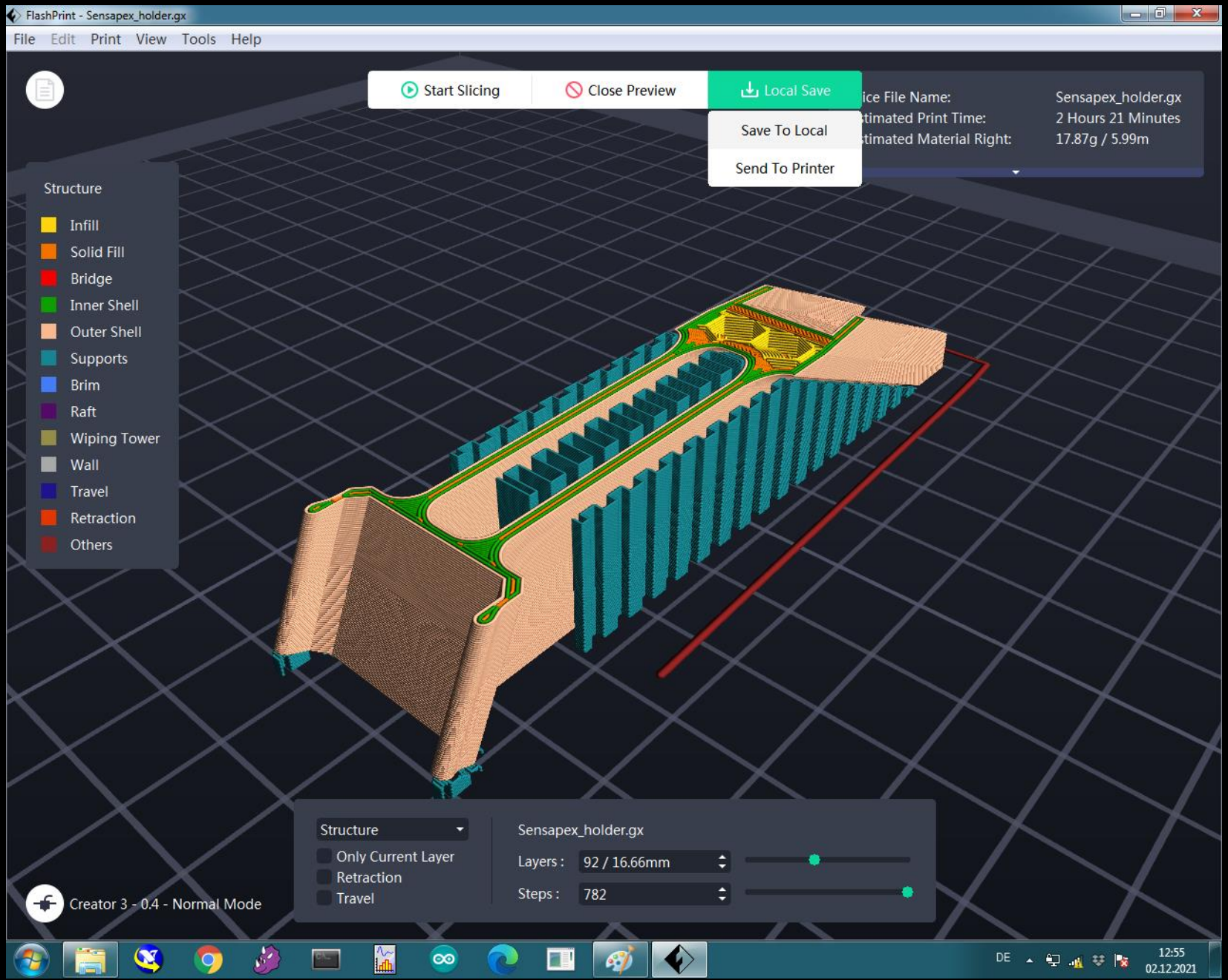

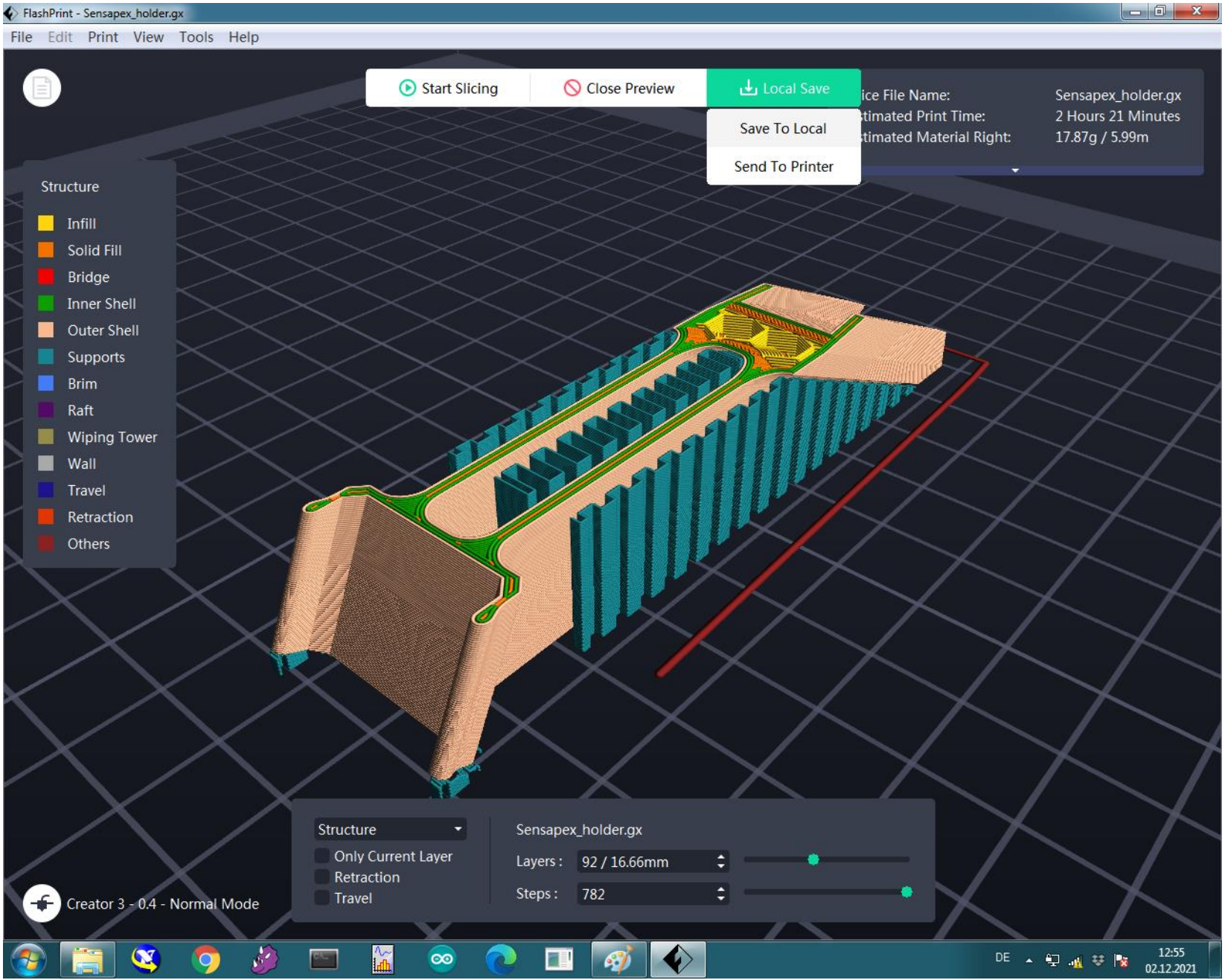
FlashPrint - Sensapex_holder.gx
File Edit Print View Tools Help
Start Slicing
Close Preview
Local Save
Save To Local
Send To Printer
ice File Name:
Sensapex_holder.gx
timated Print Time:
2 Hours 21 Minutes
timated Material Right:
17.87g / 5.99m
Structure
Infill
Solid Fill
Bridge
Inner Shell
Outer Shell
Supports
Brim
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Wall
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Retraction
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Sensapex_holder.gx
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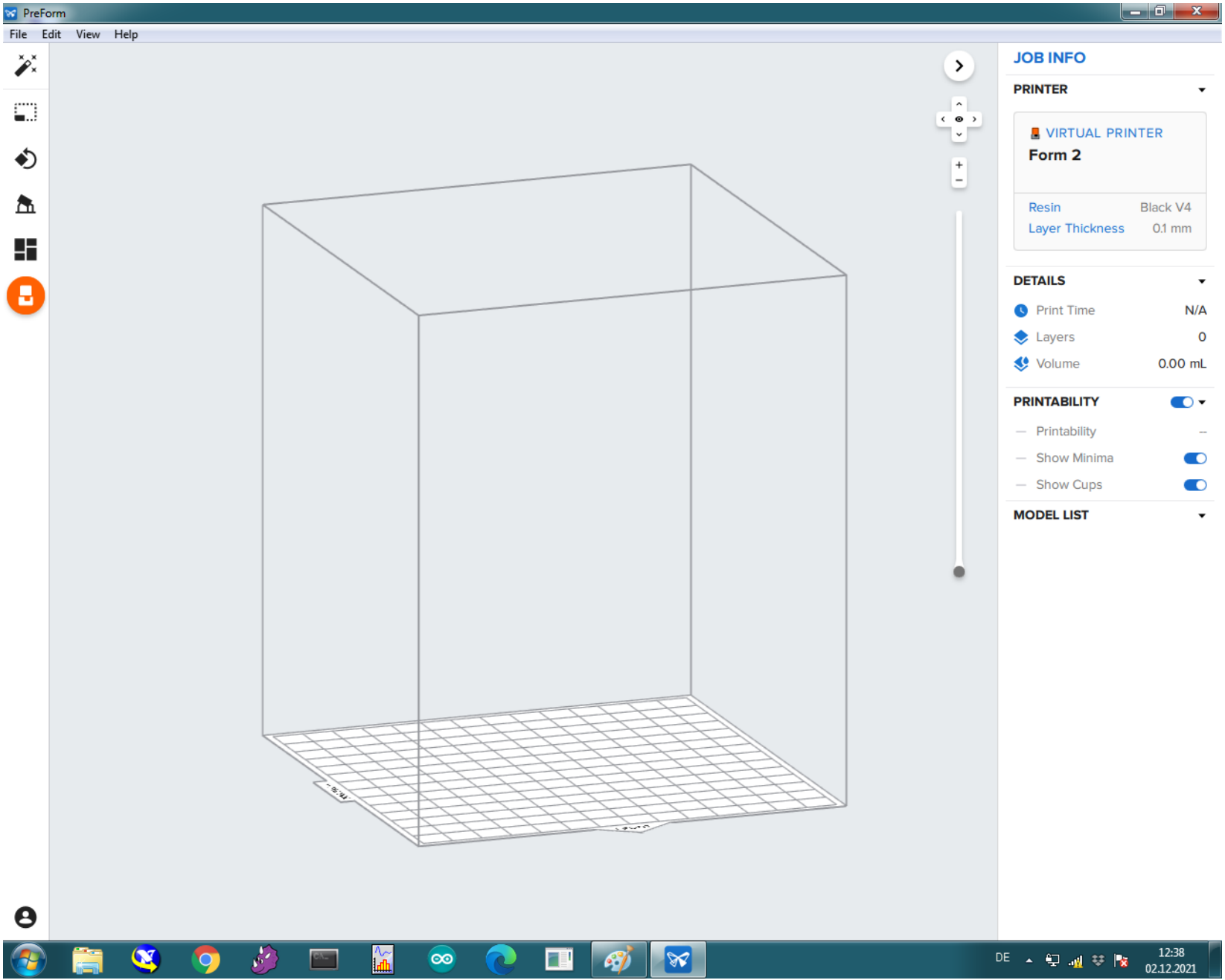
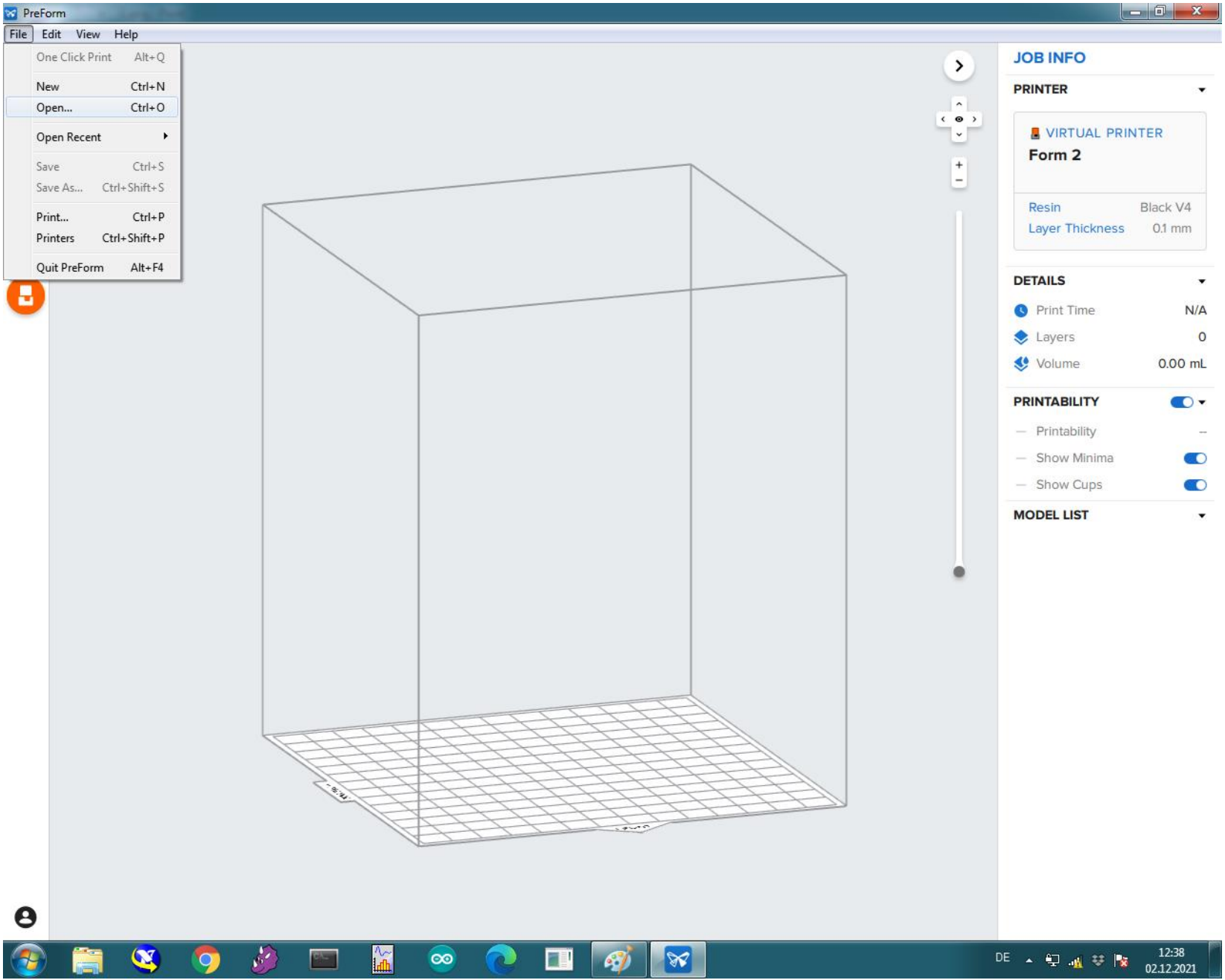
Creator 3 - 0.4 - Normal Mode
DE
12:55
02.12.2021

How to print with the Formlabs Form 2

How to print: Form 2



How to print: Form 2



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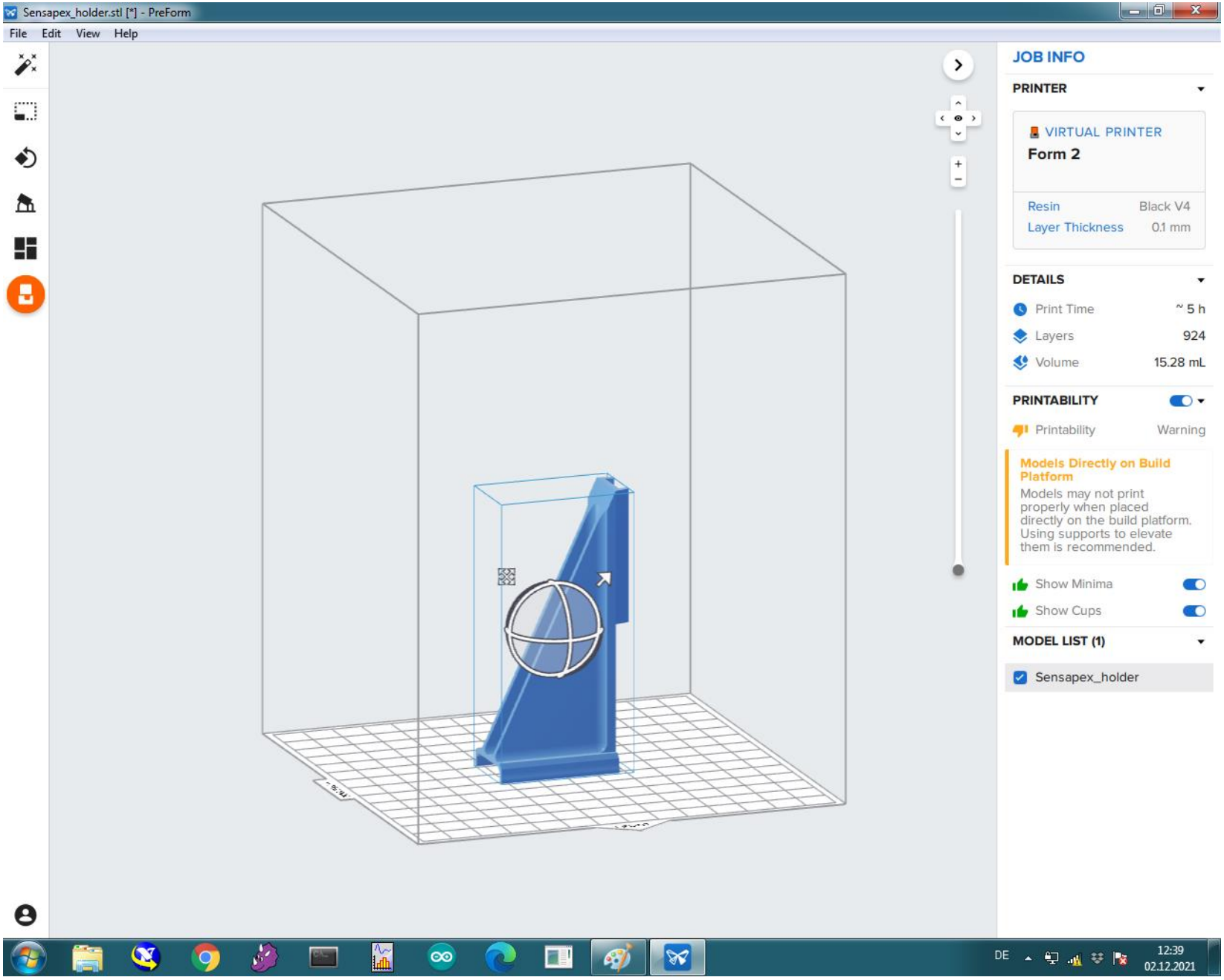

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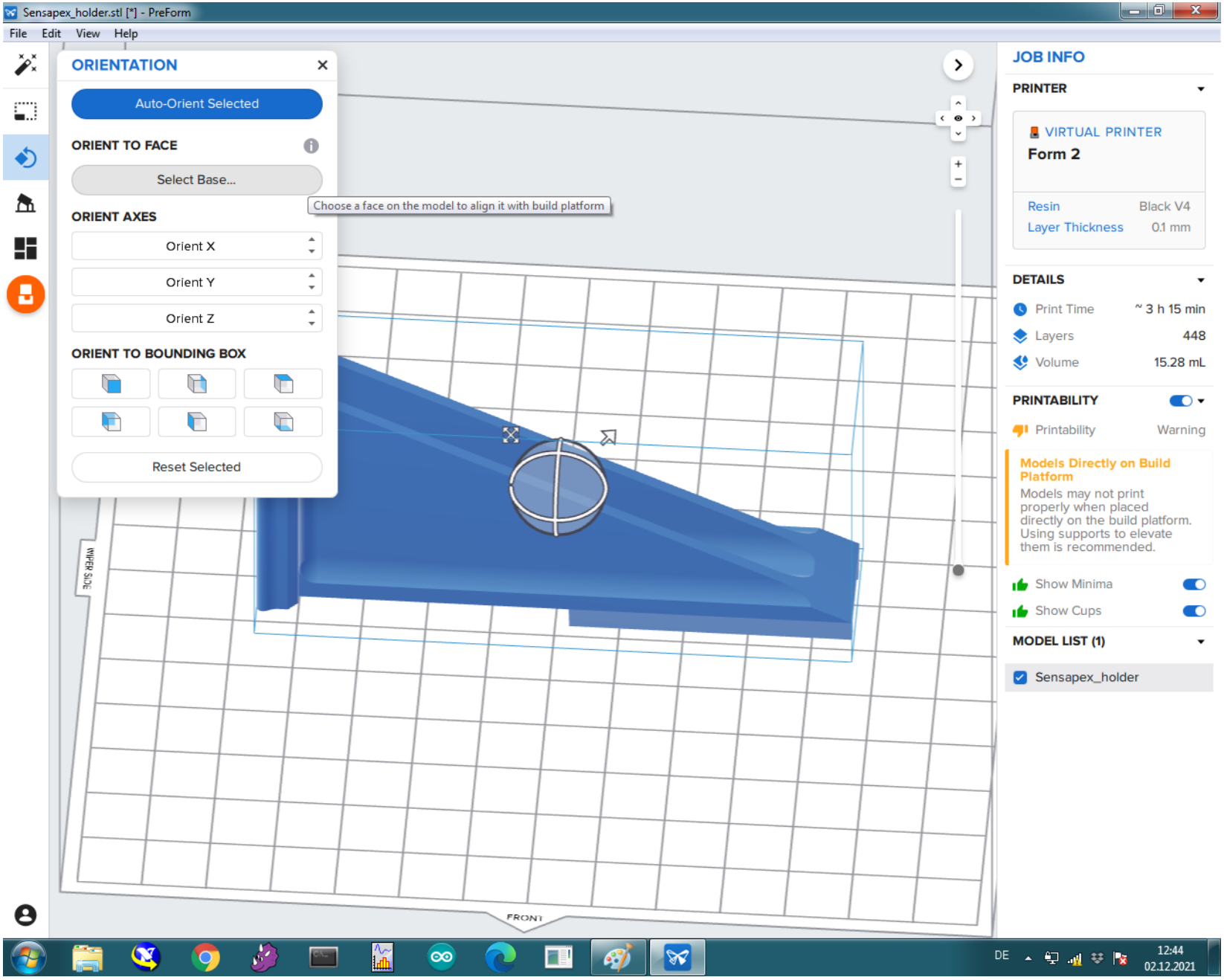

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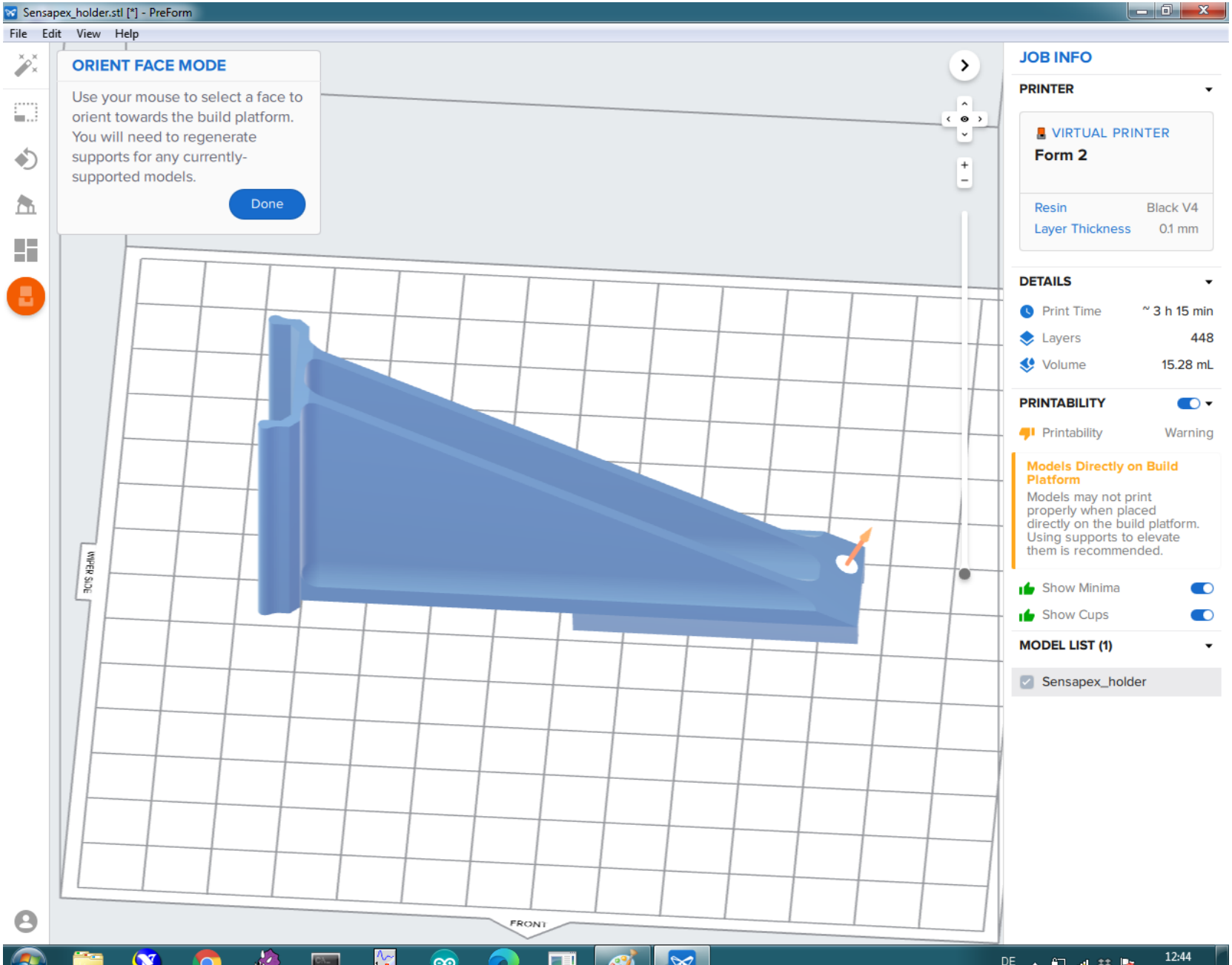

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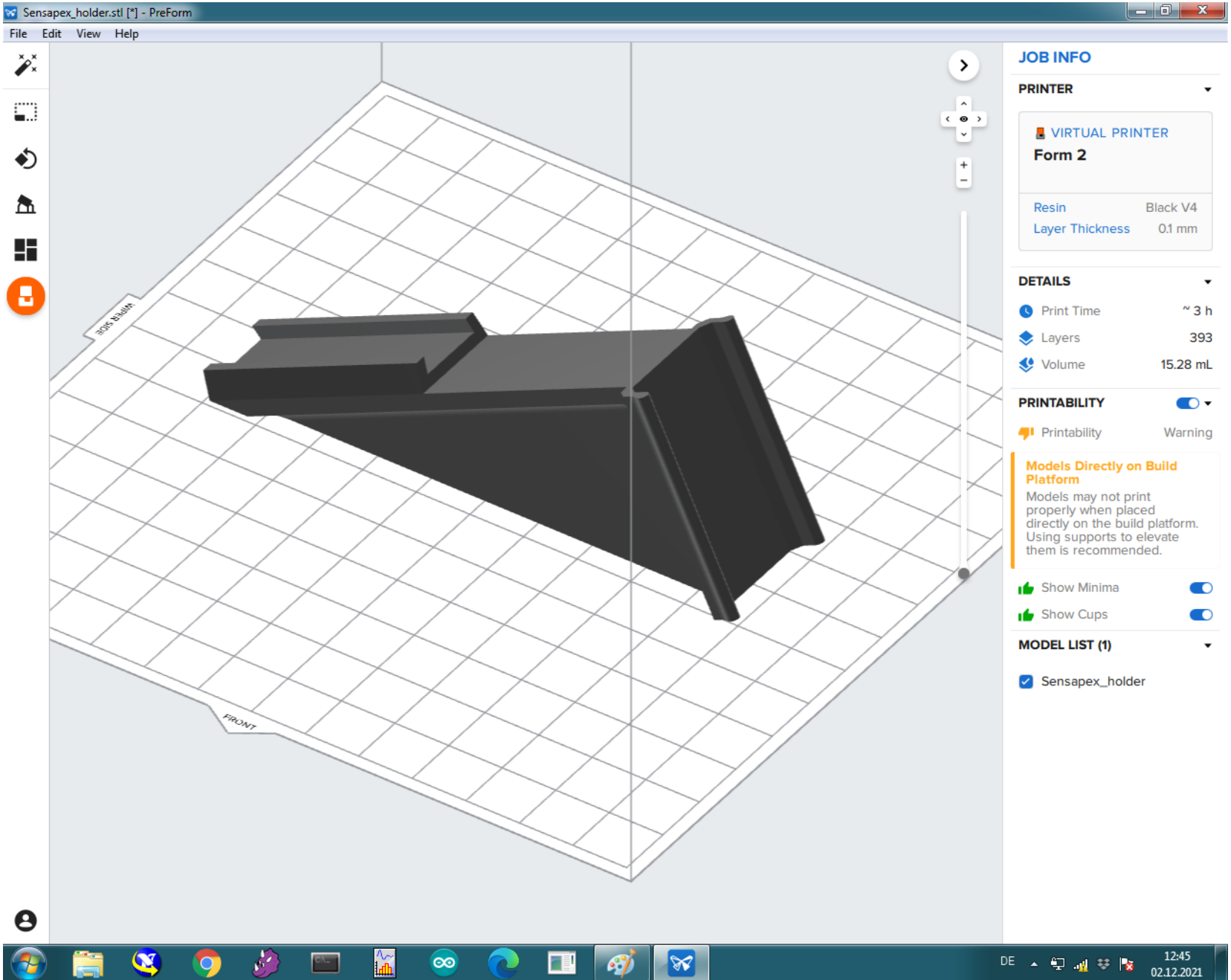

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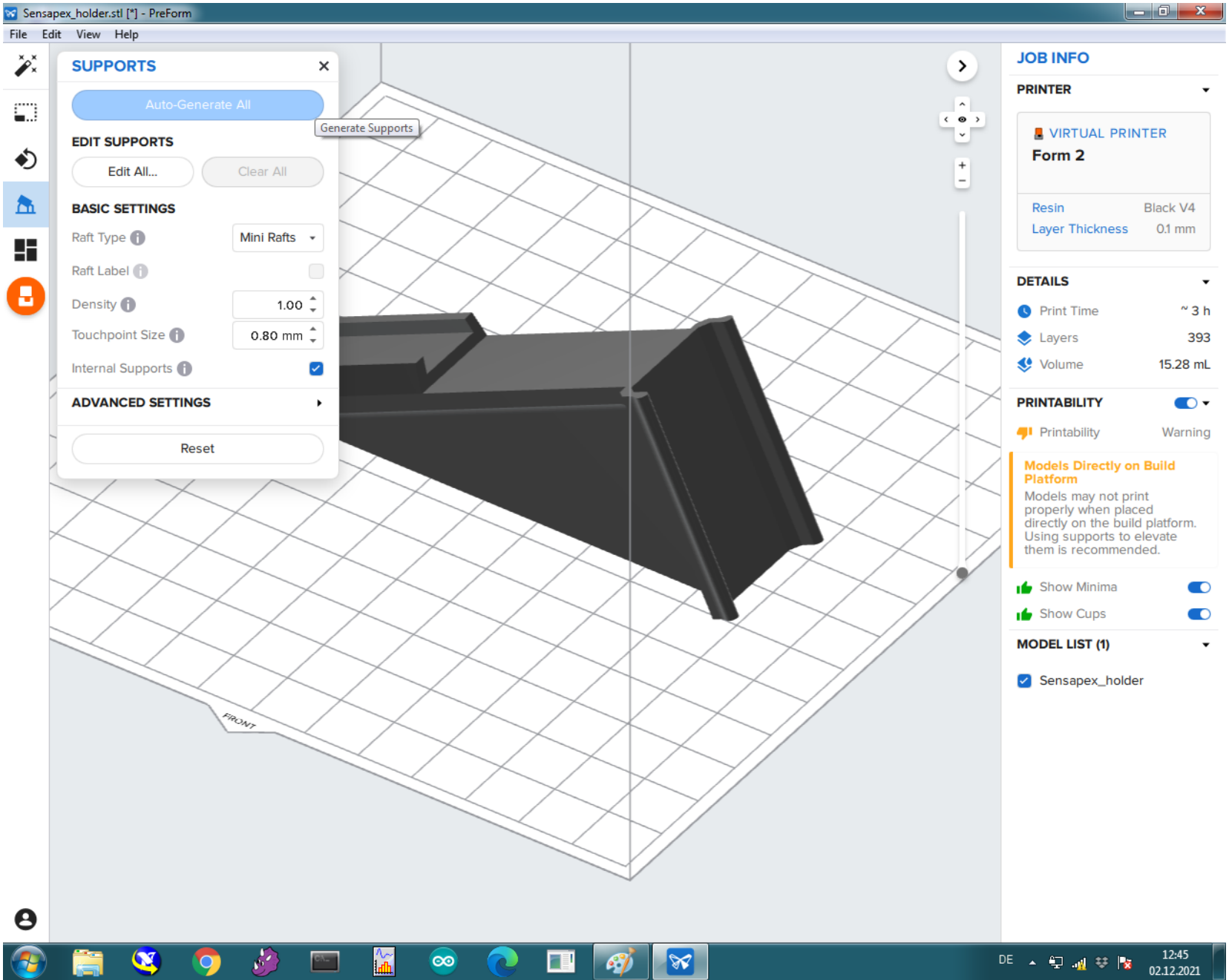

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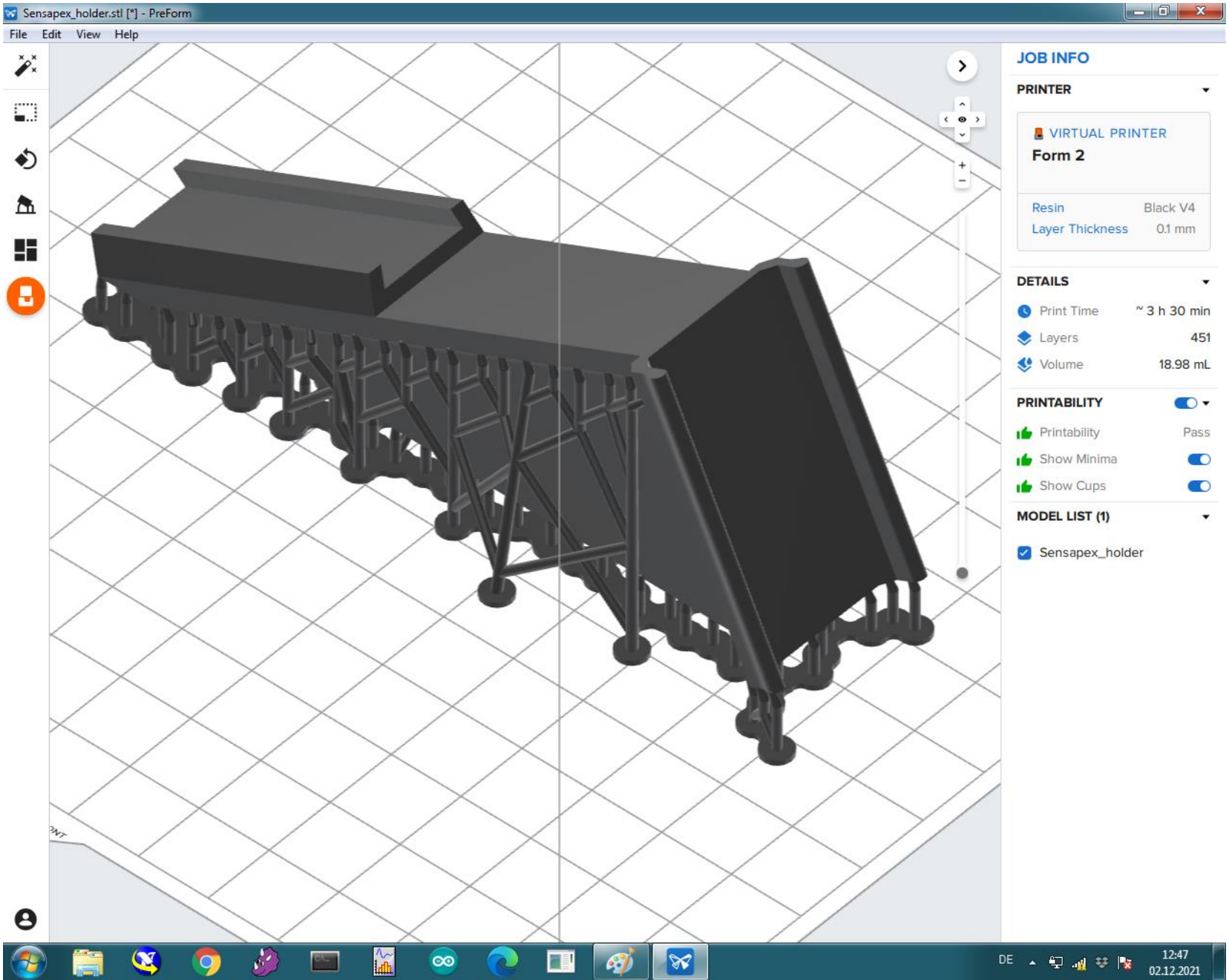

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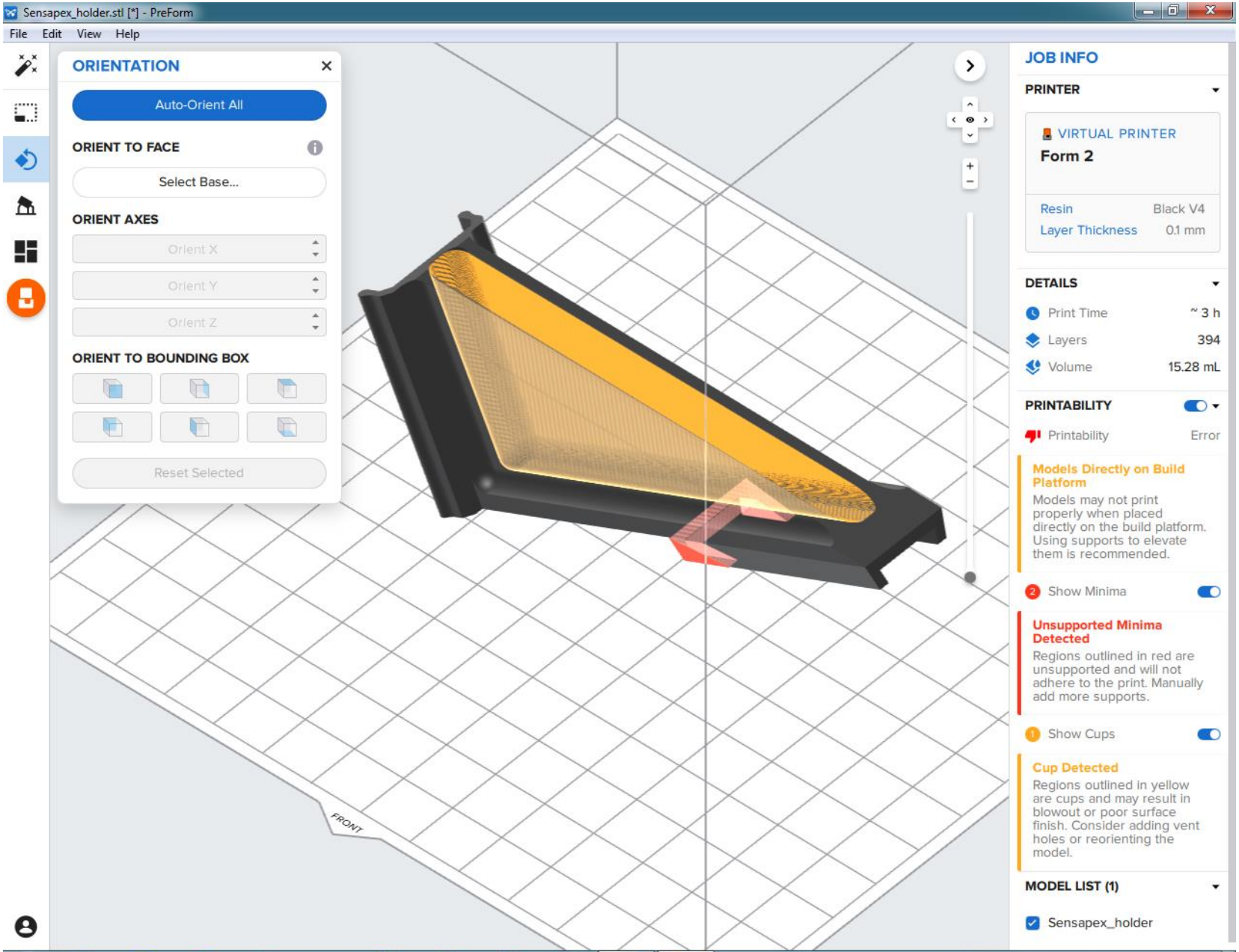
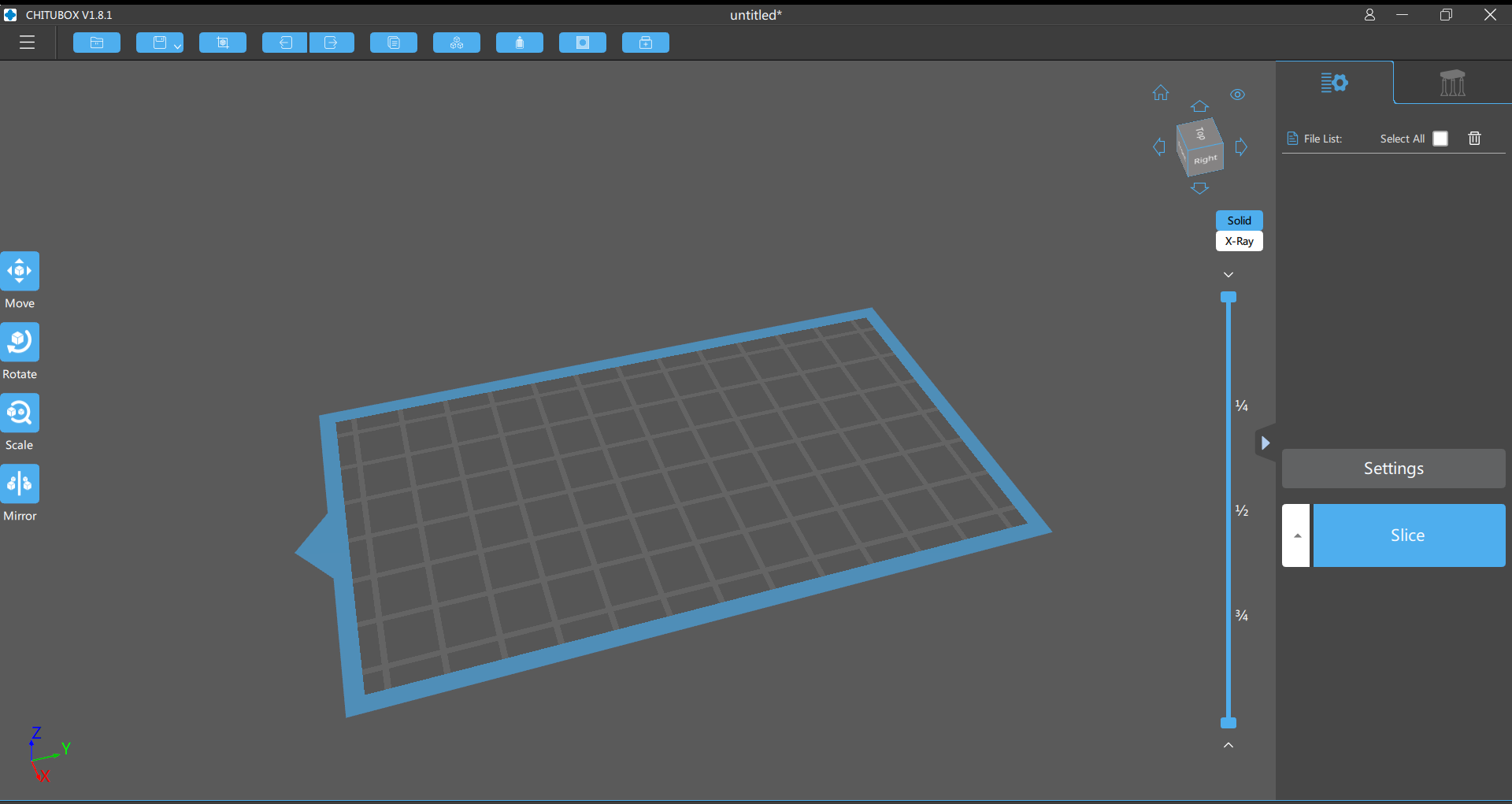


How to print with the Creality LD002

How to print: Creality LD002



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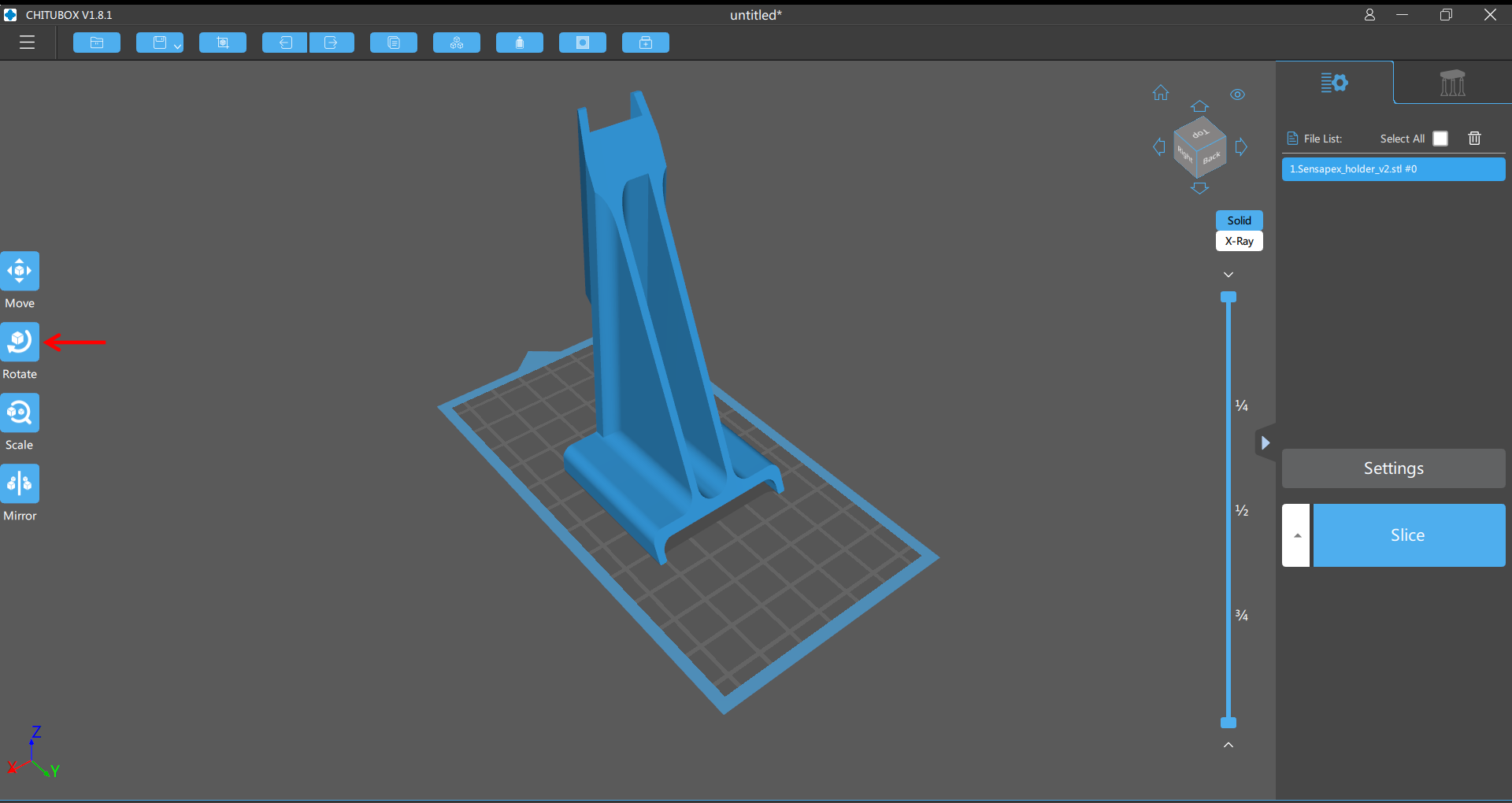

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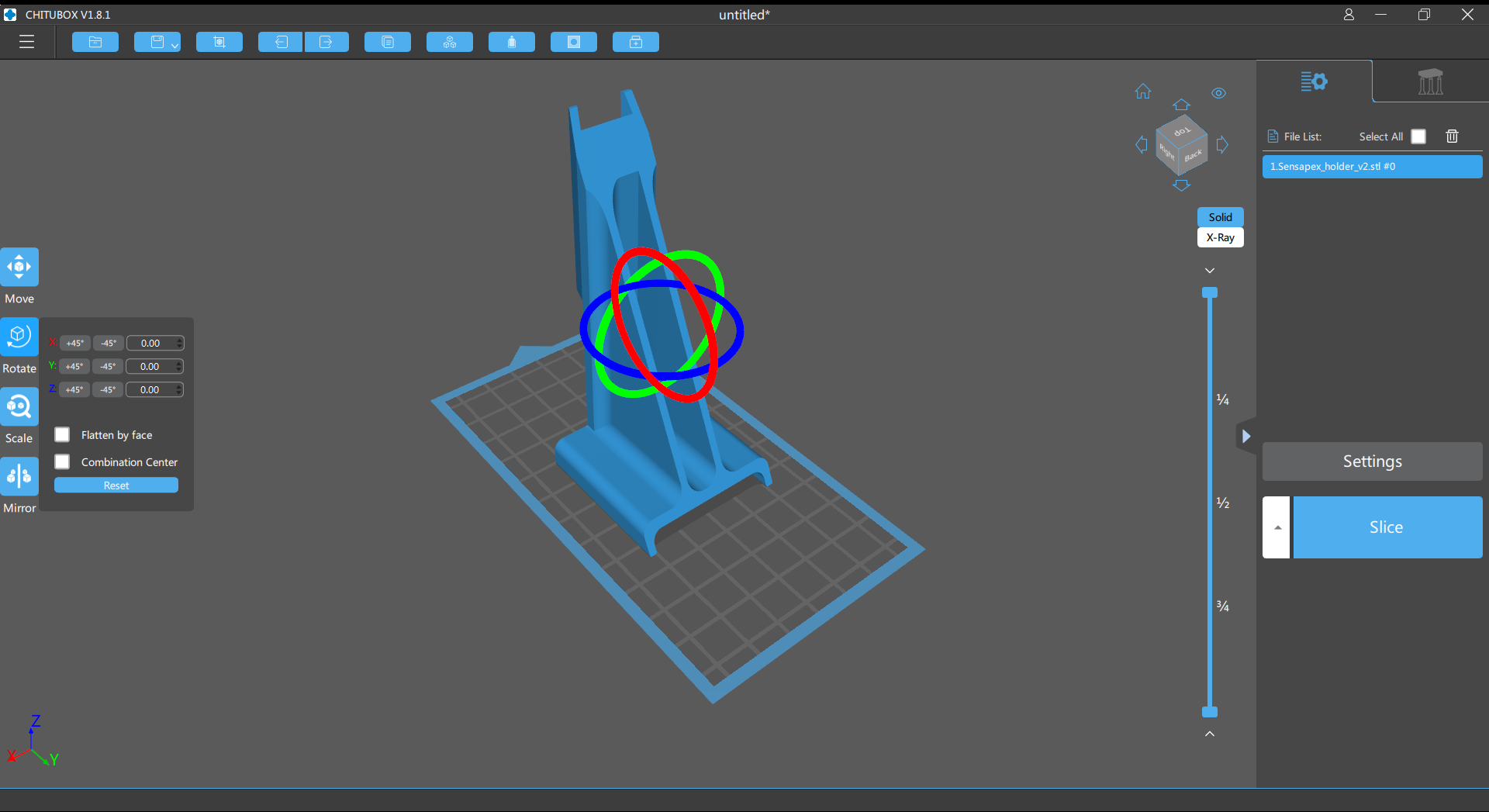

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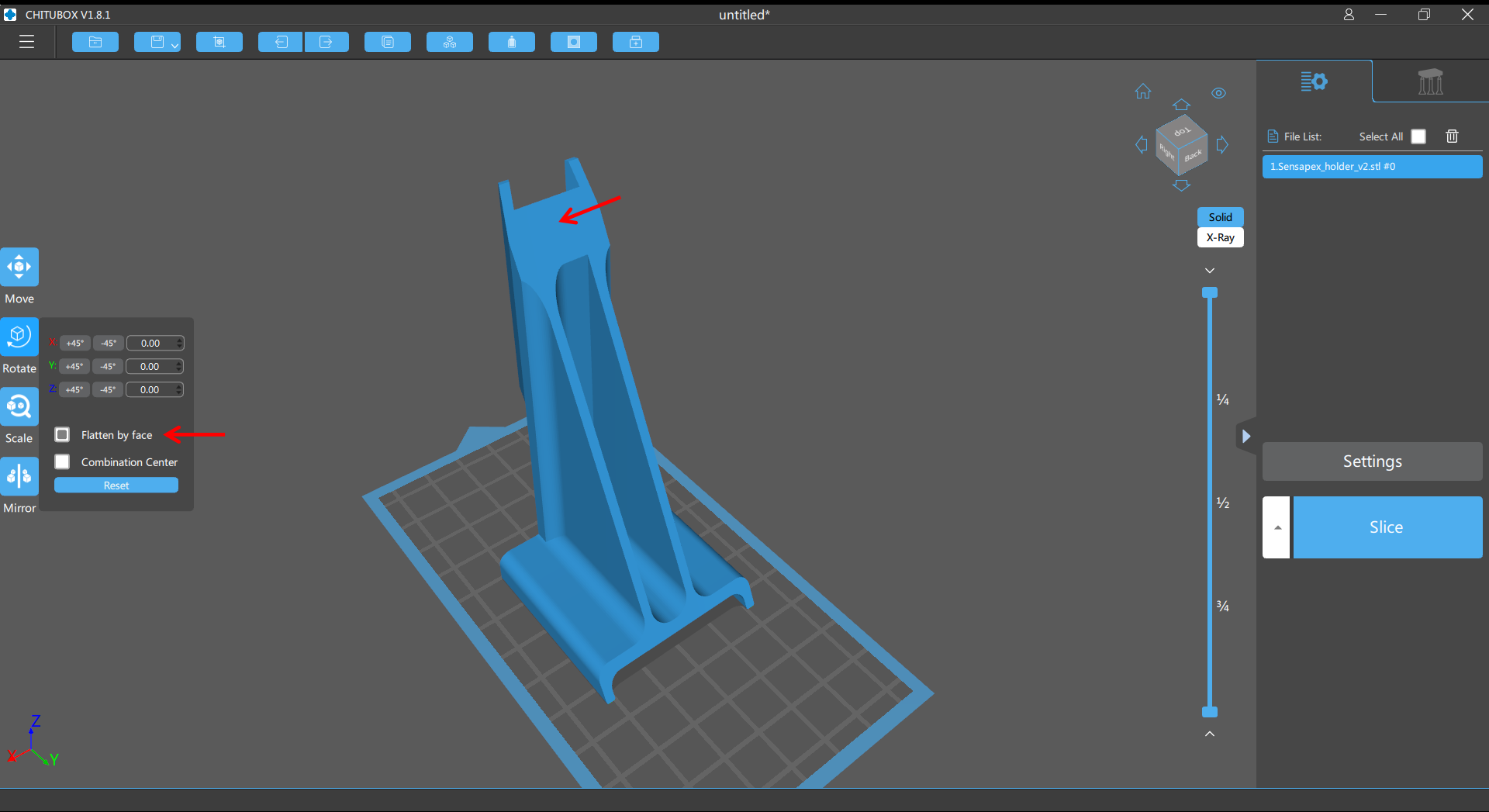

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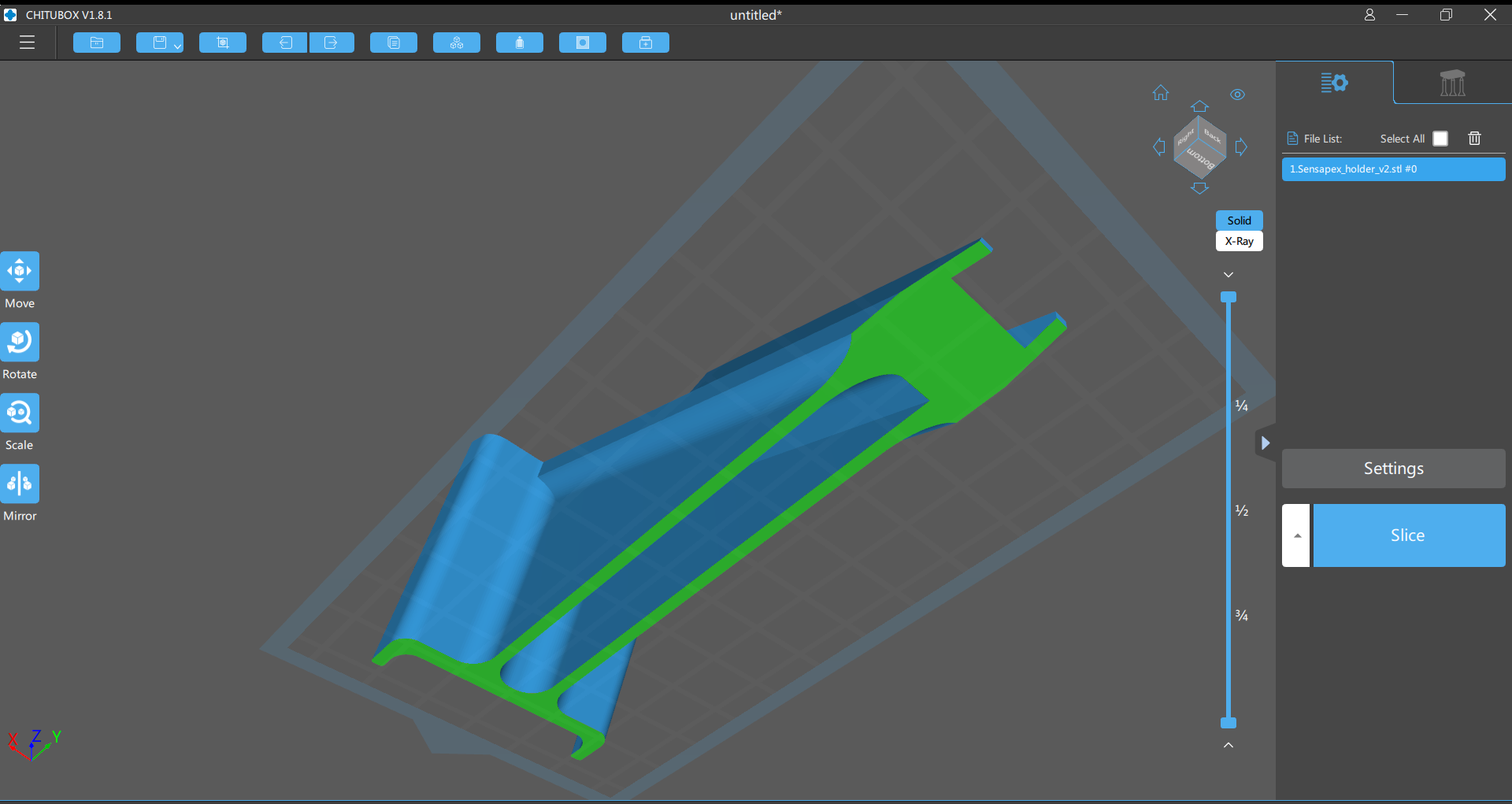

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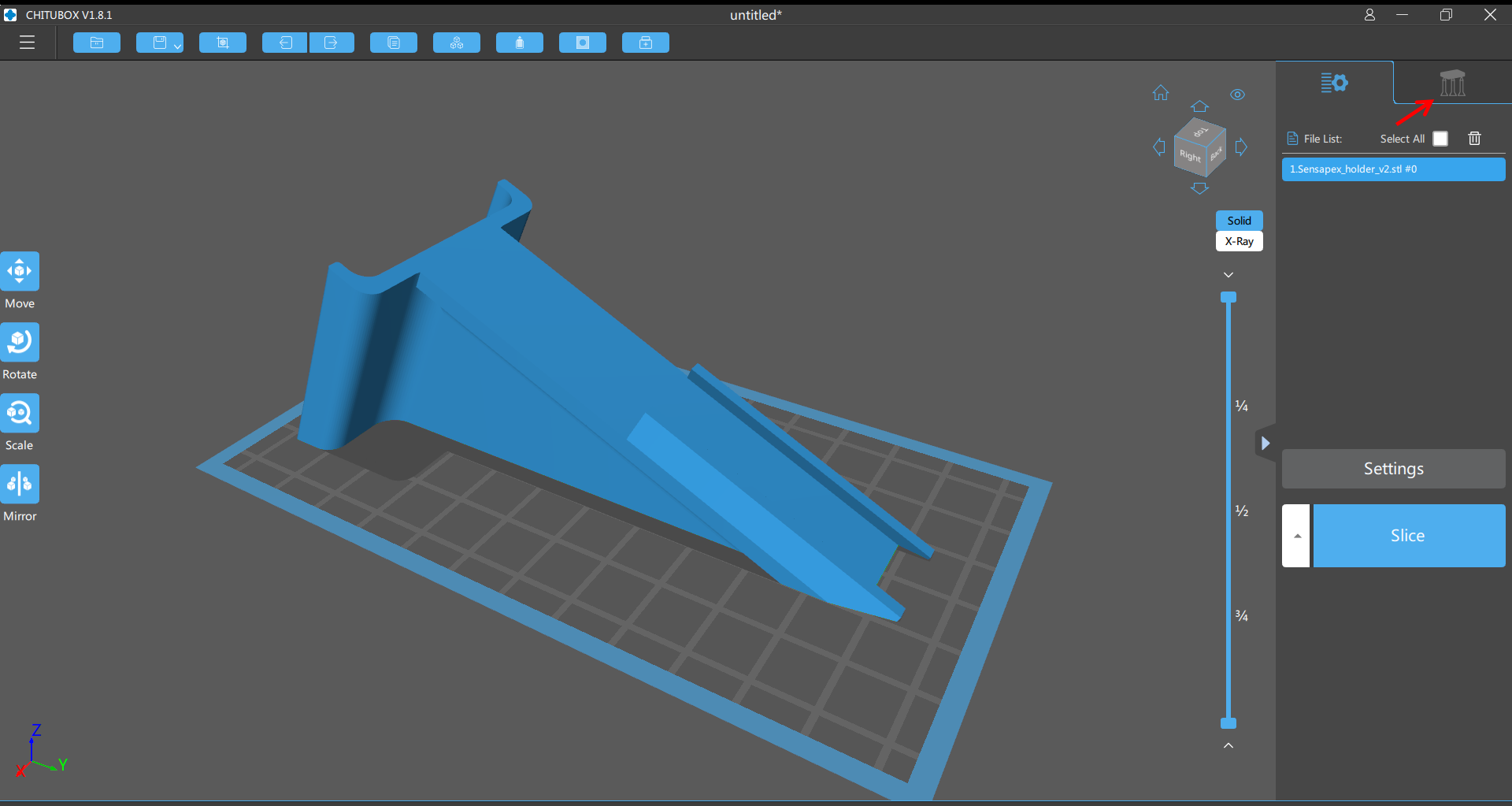

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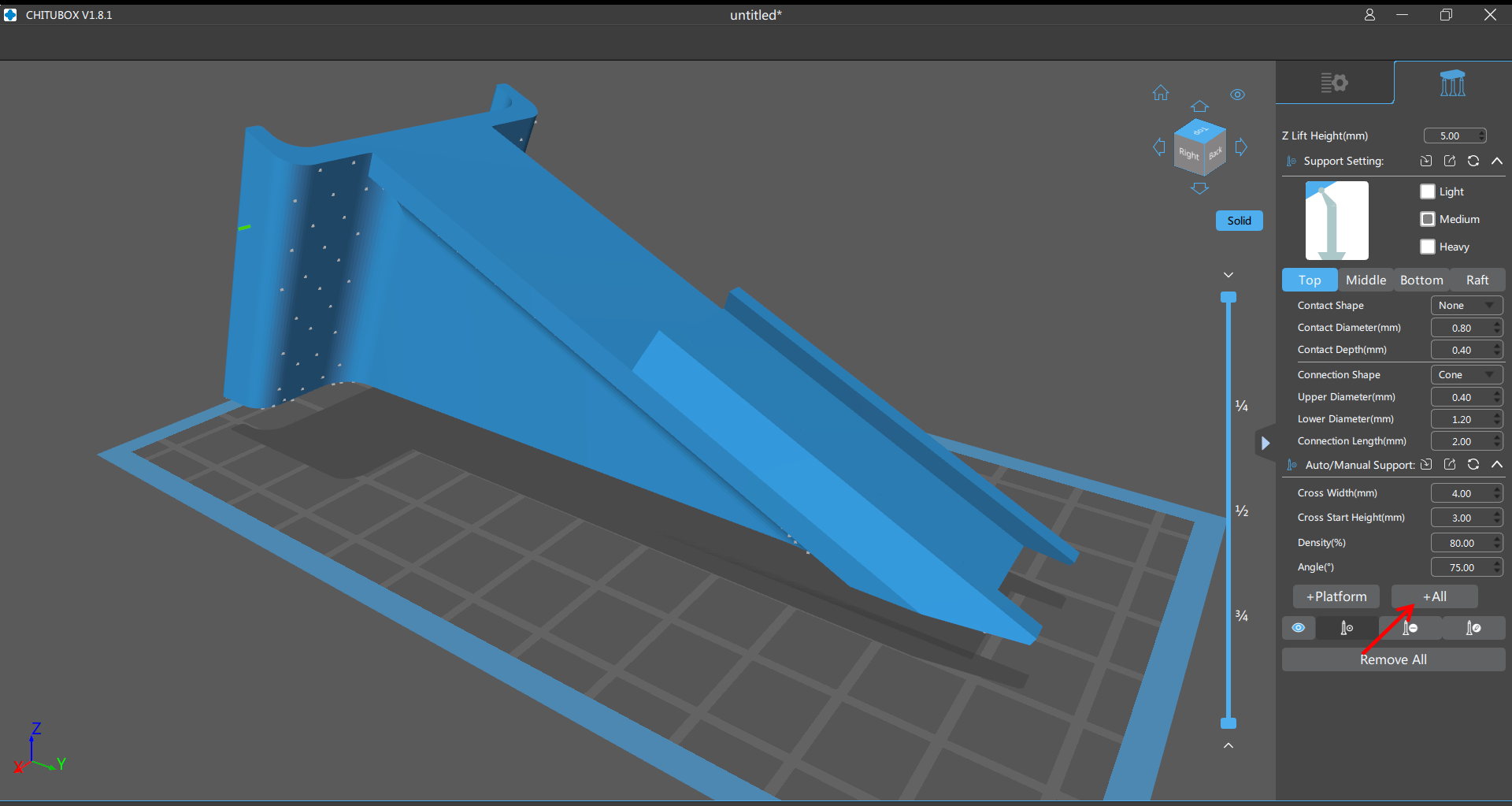

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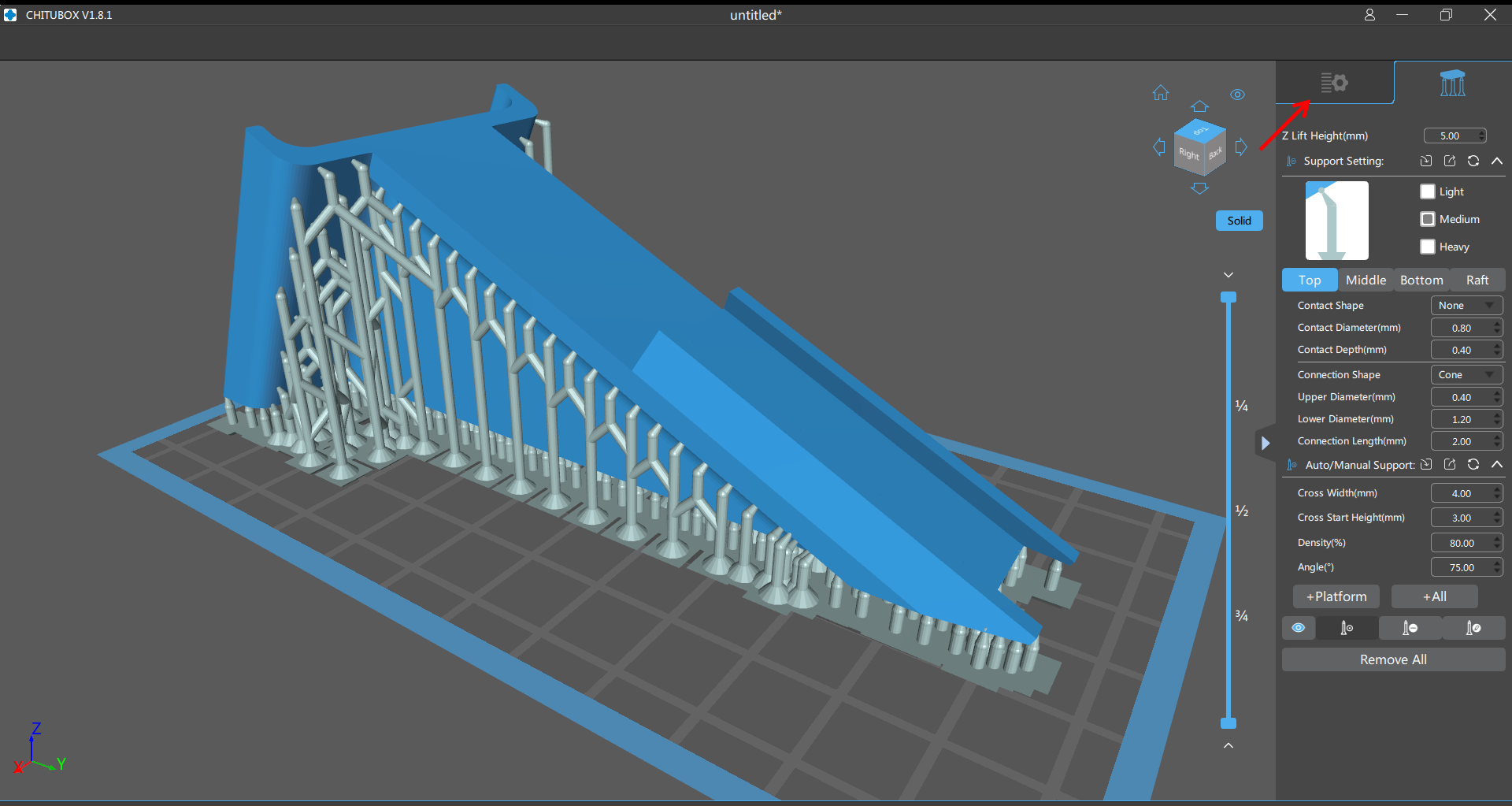

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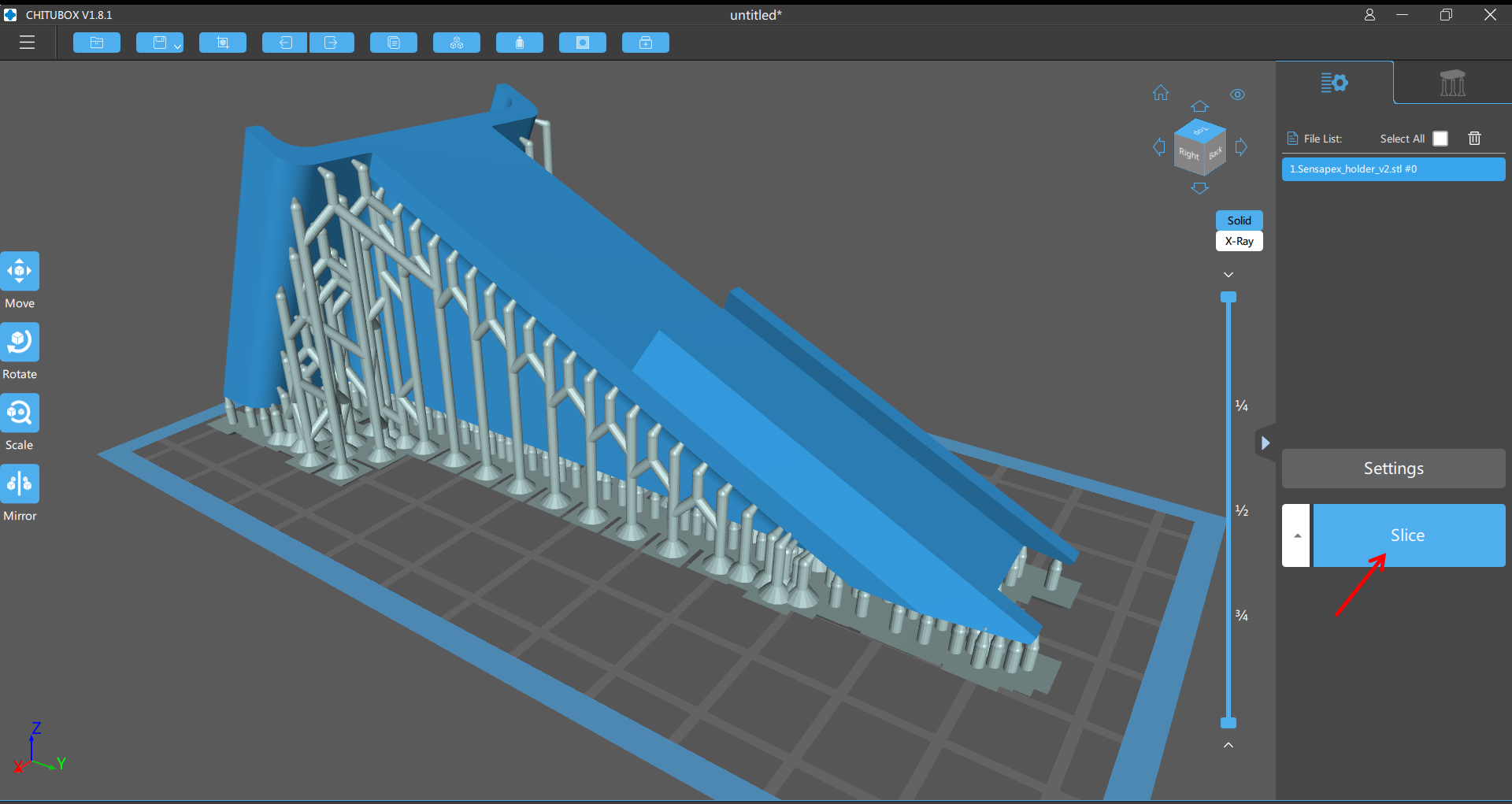

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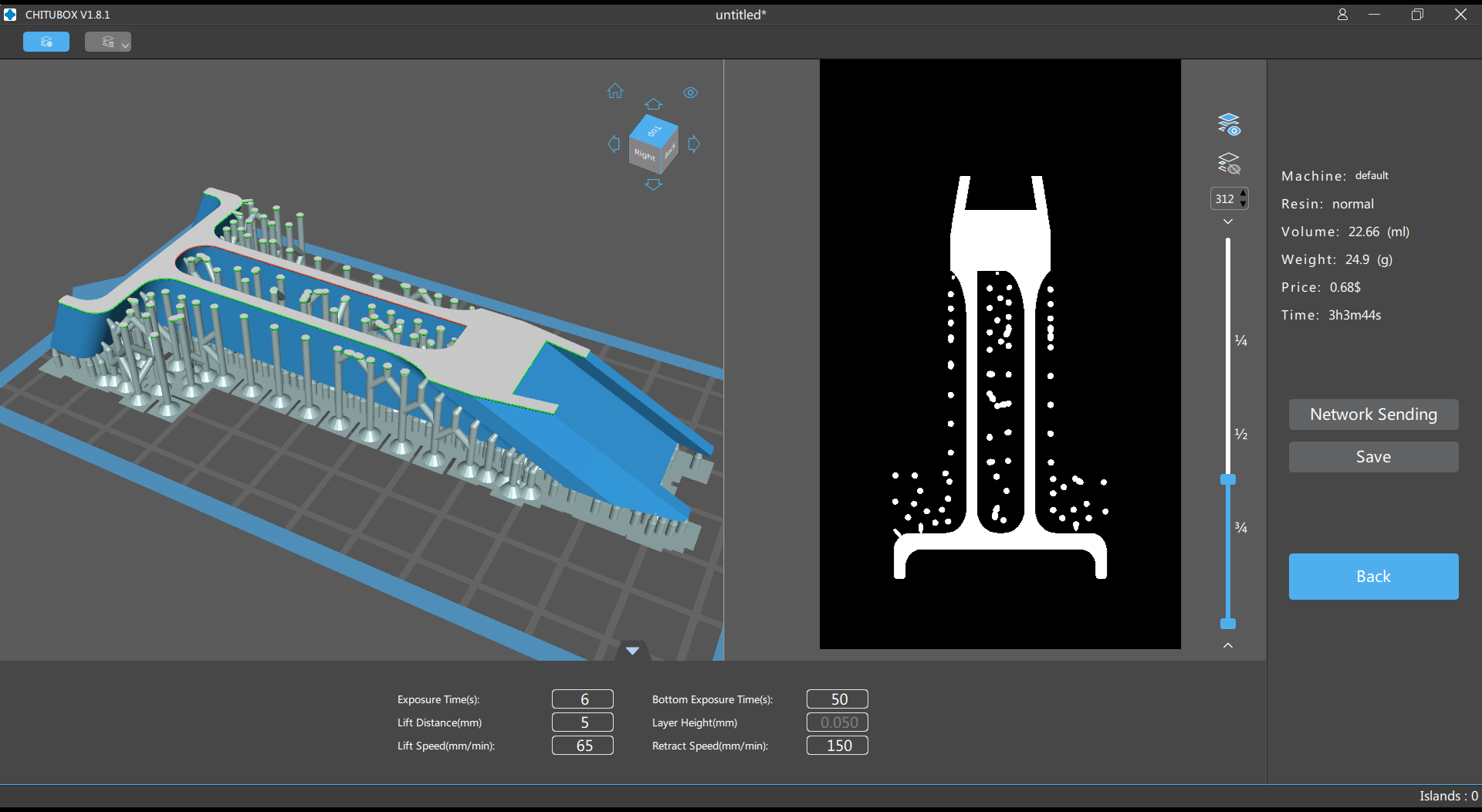

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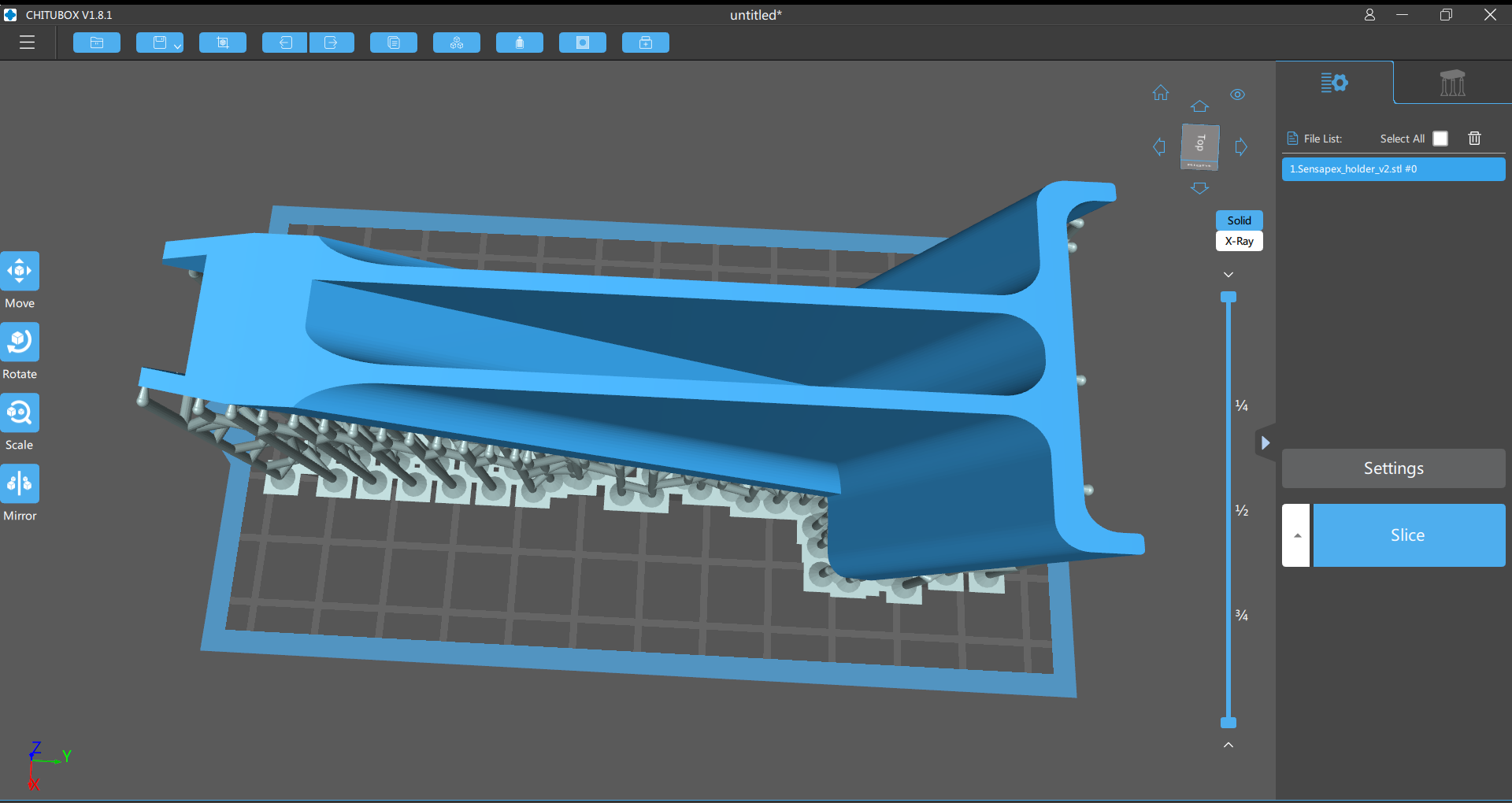


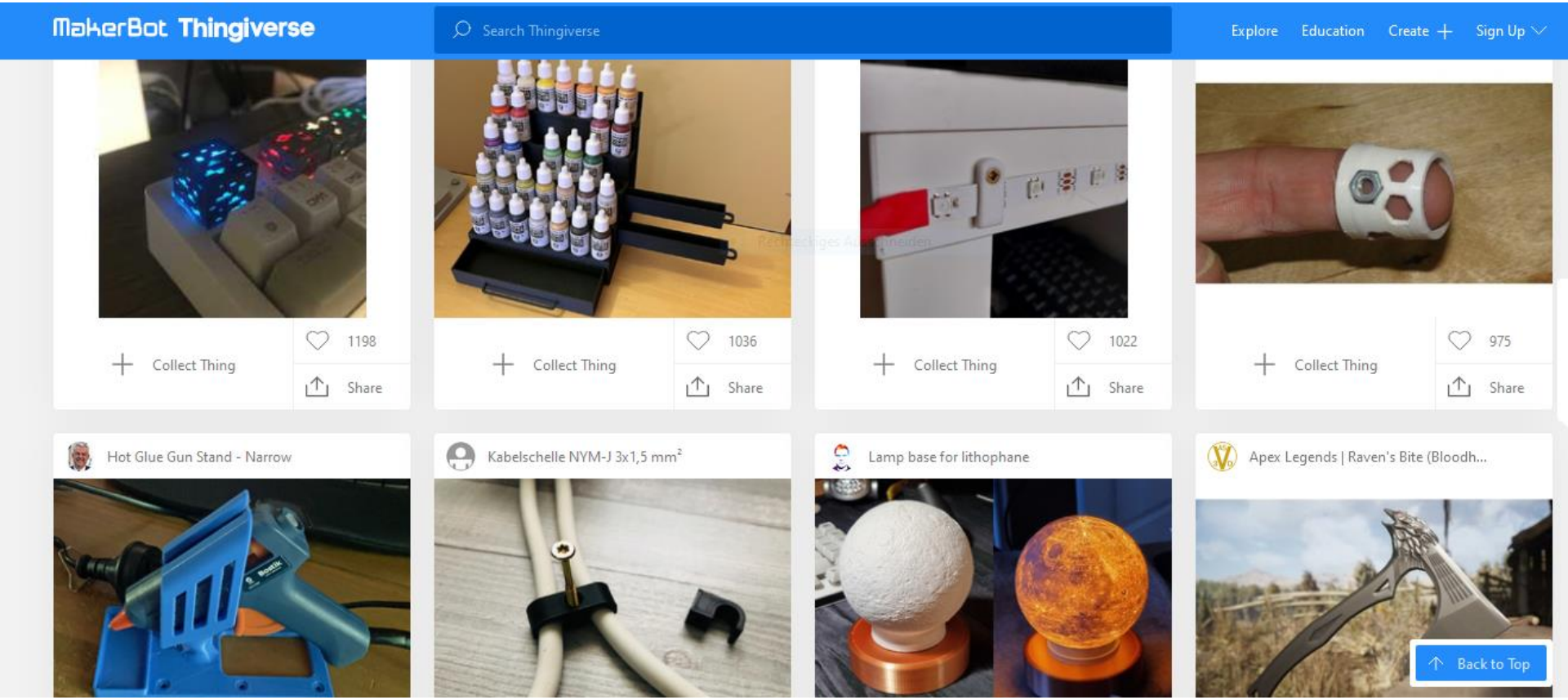
Washing and curing with Anycubic Wash and cure station

Outlook

- Many online repositories where 3D models can be downloaded for free

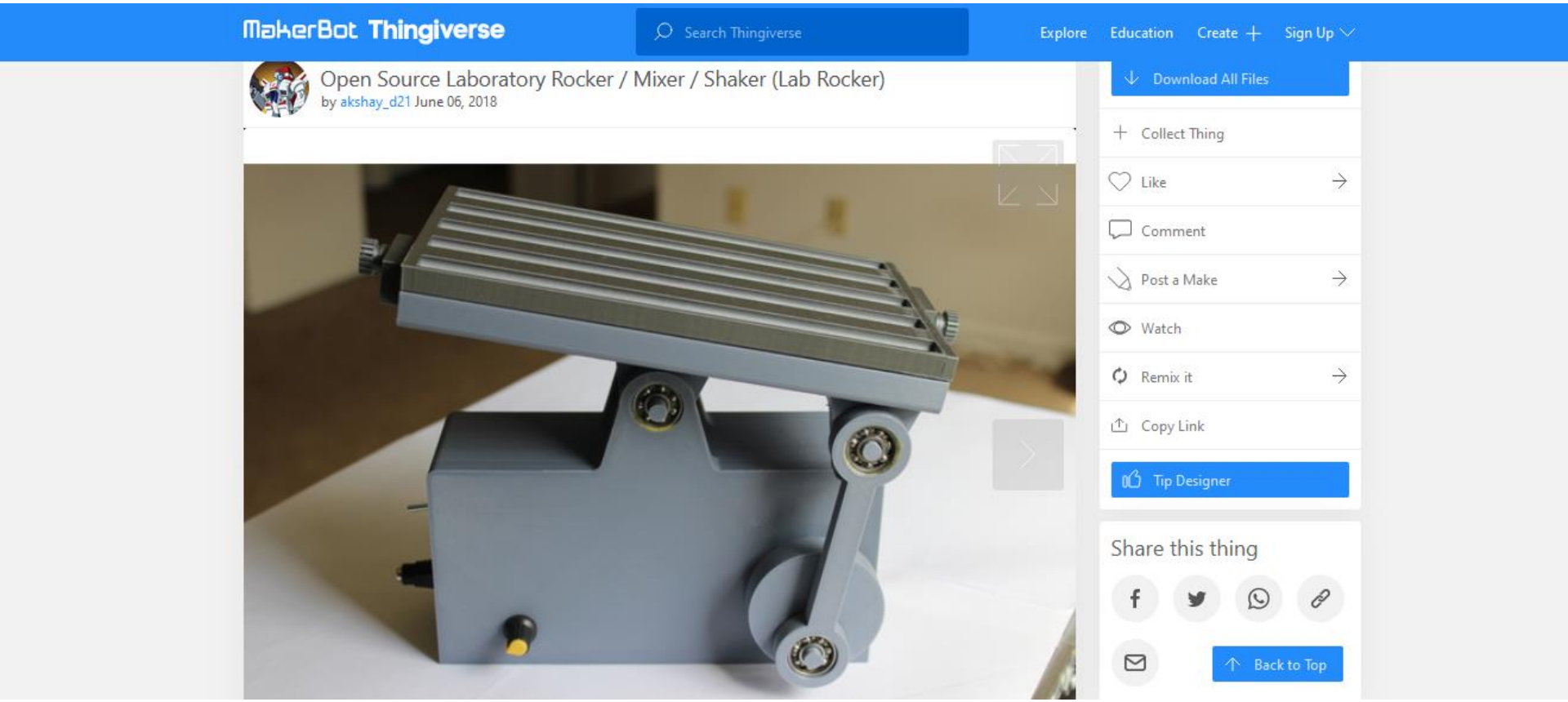
Outlook

- www.thingiverse.com



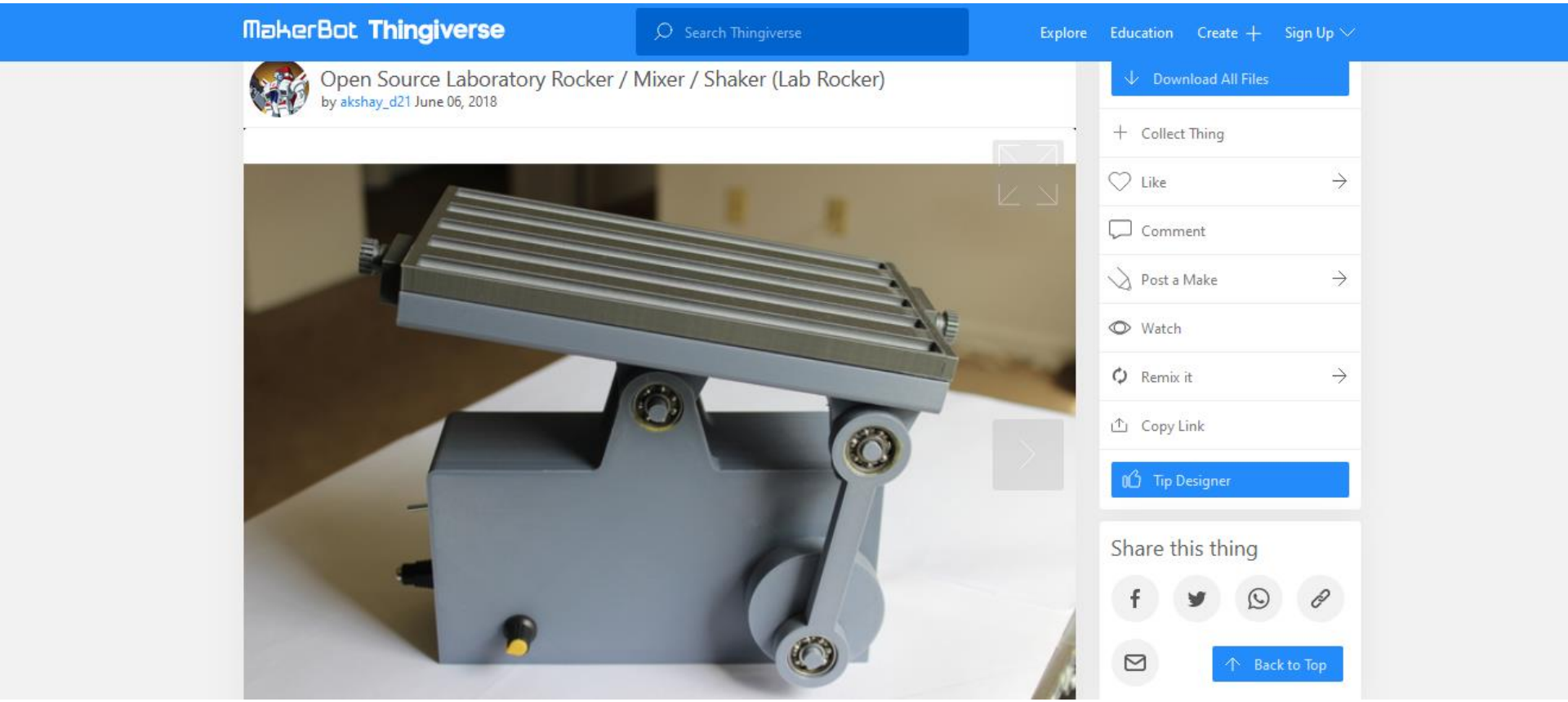
Outlook

- www.thingiverse.com



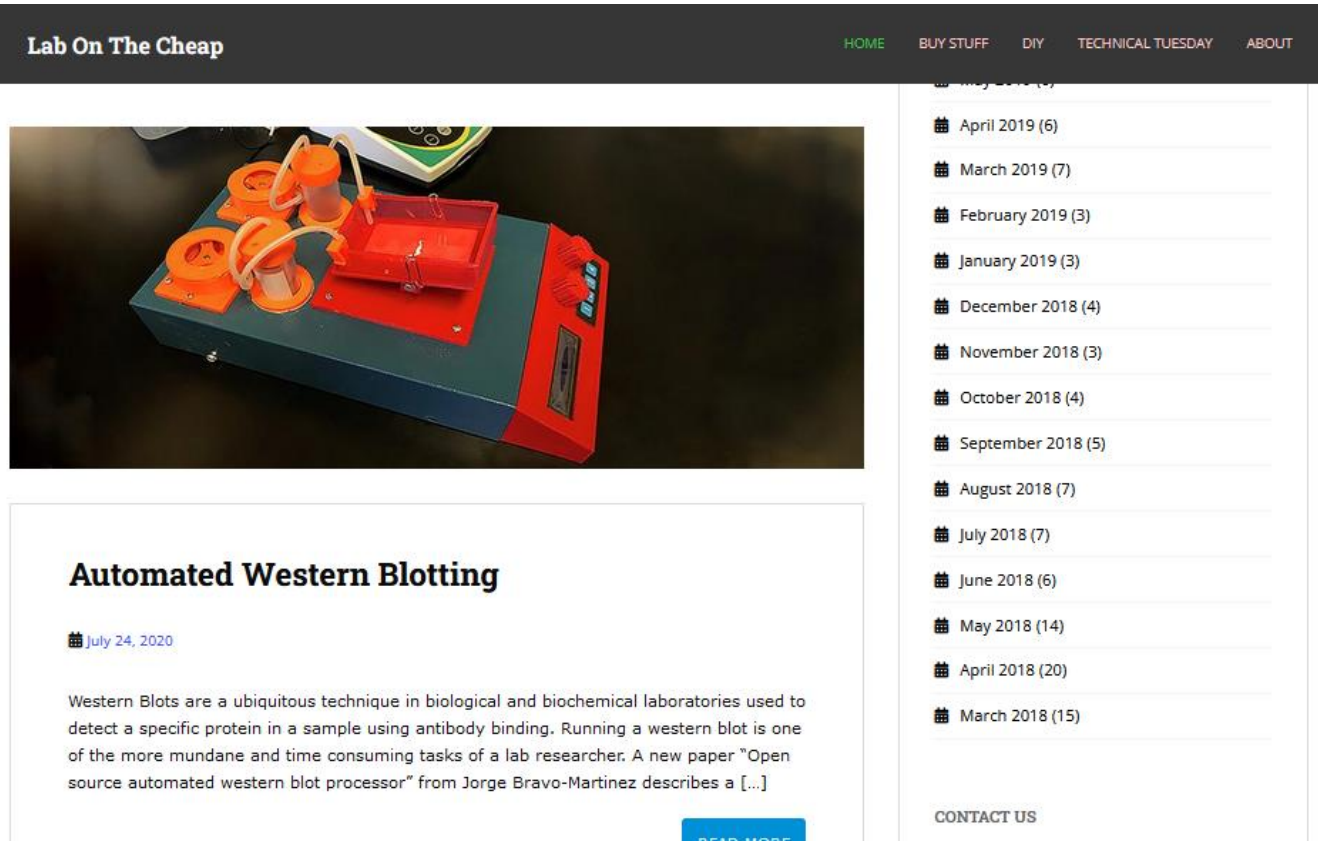
Outlook

- www.thingiverse.com



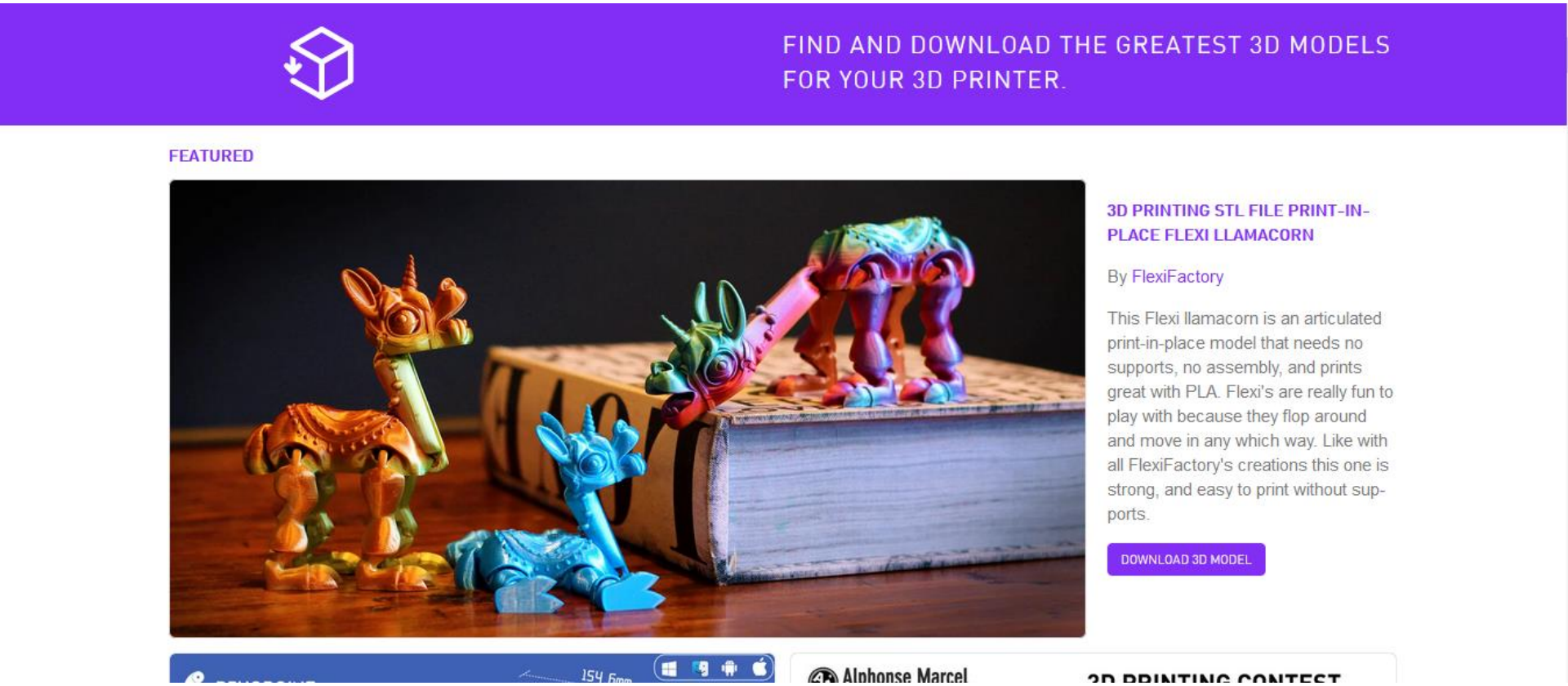
Outlook

- www.labonthecheap.com



Outlook

- www.cults3d.com



Outlook

- Other useful places:
  - www.hackaday.com
  - www.instuctables.com
  - github

Thank you for your attention!