htmaa

eecs section

week 3

group assignment

3d printing design rules

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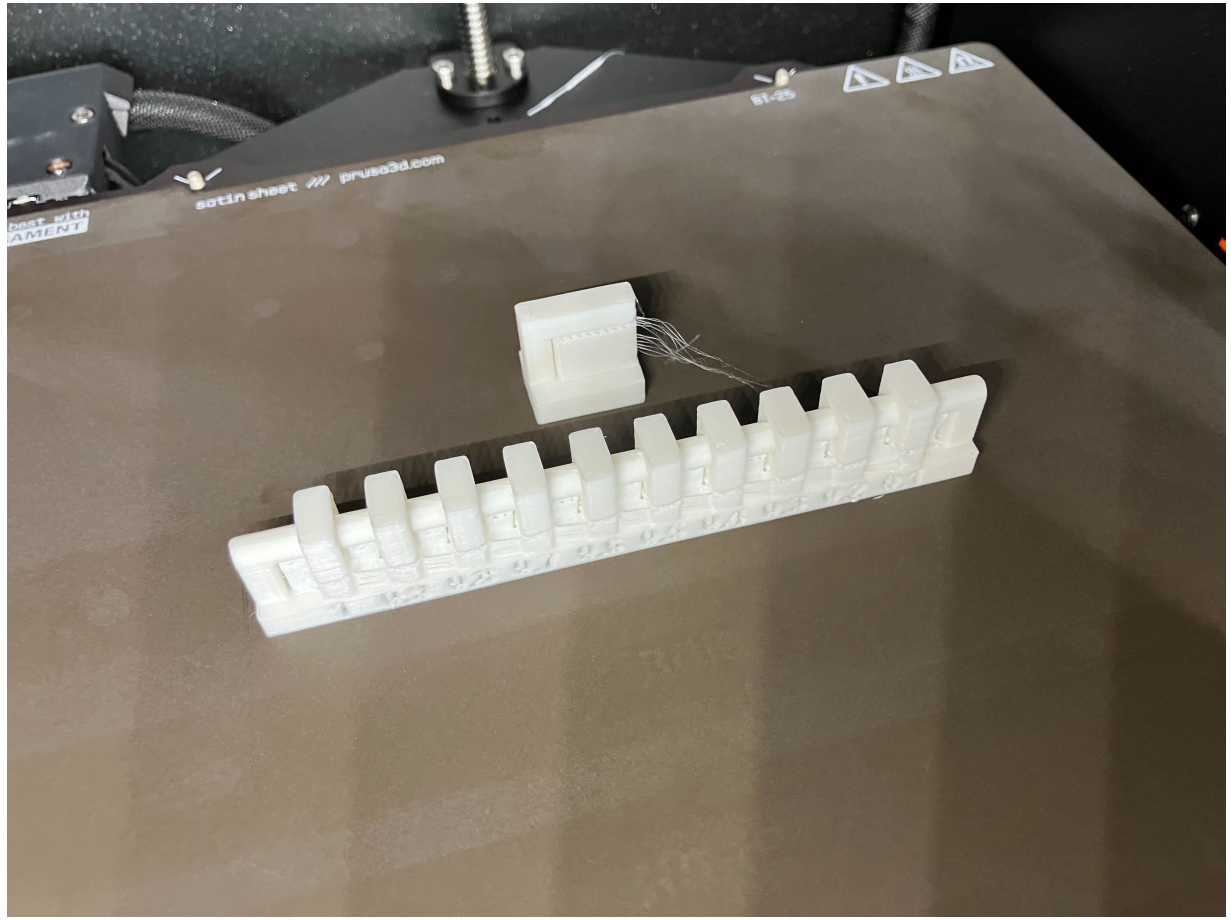
Supported tests

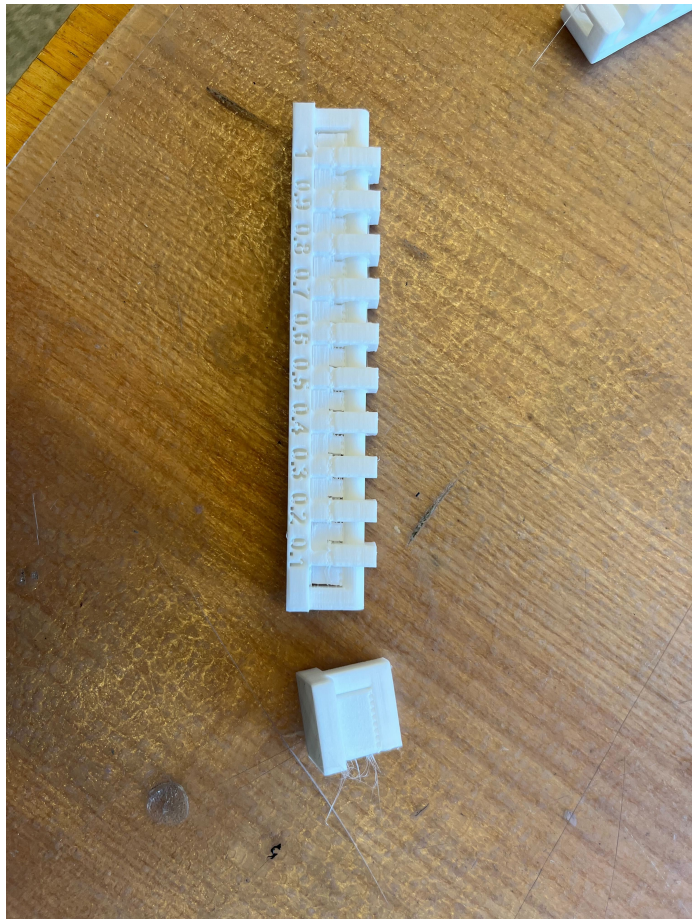
- Overhangs
- Clearance

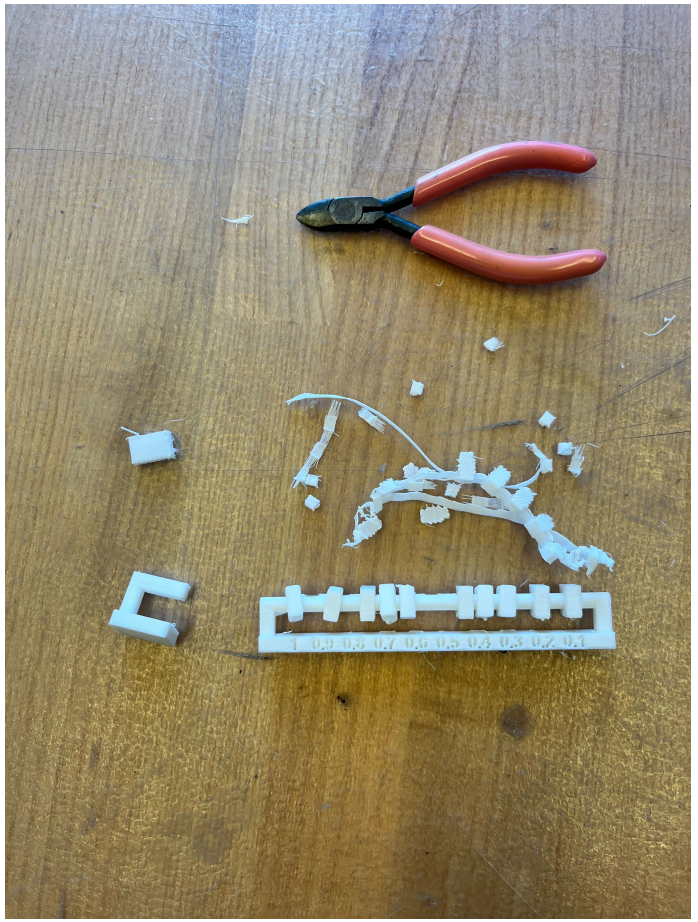


Printer

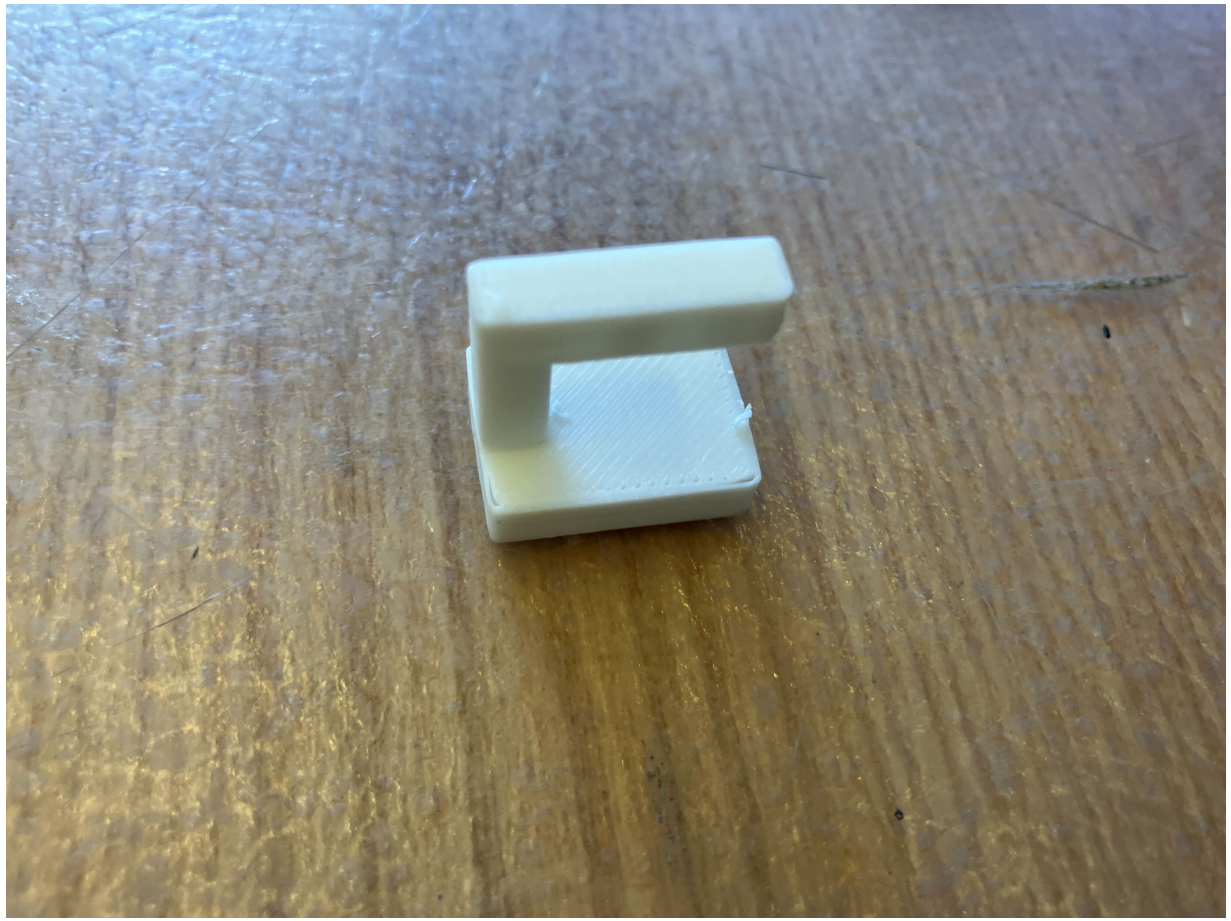
- Pruse Core One
- Printed with white generic PLA

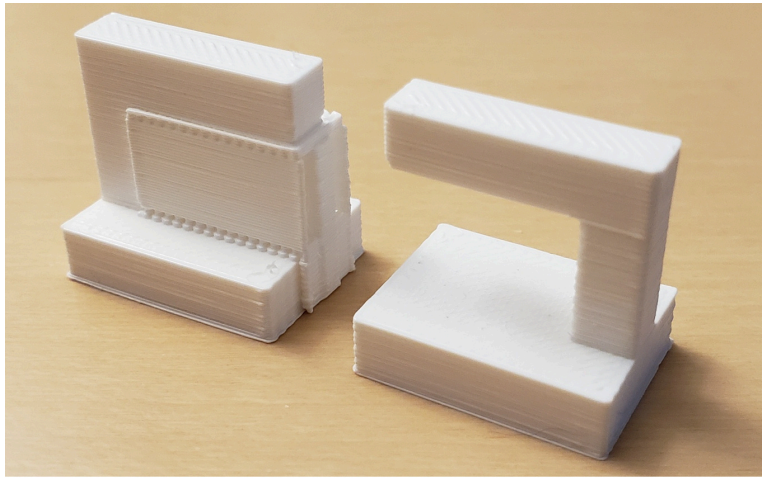
Removing support with pliers

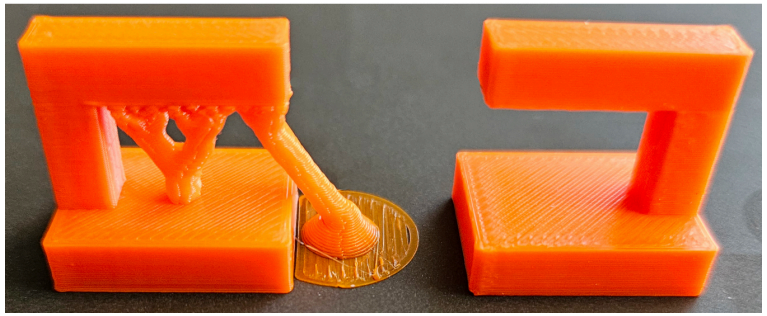




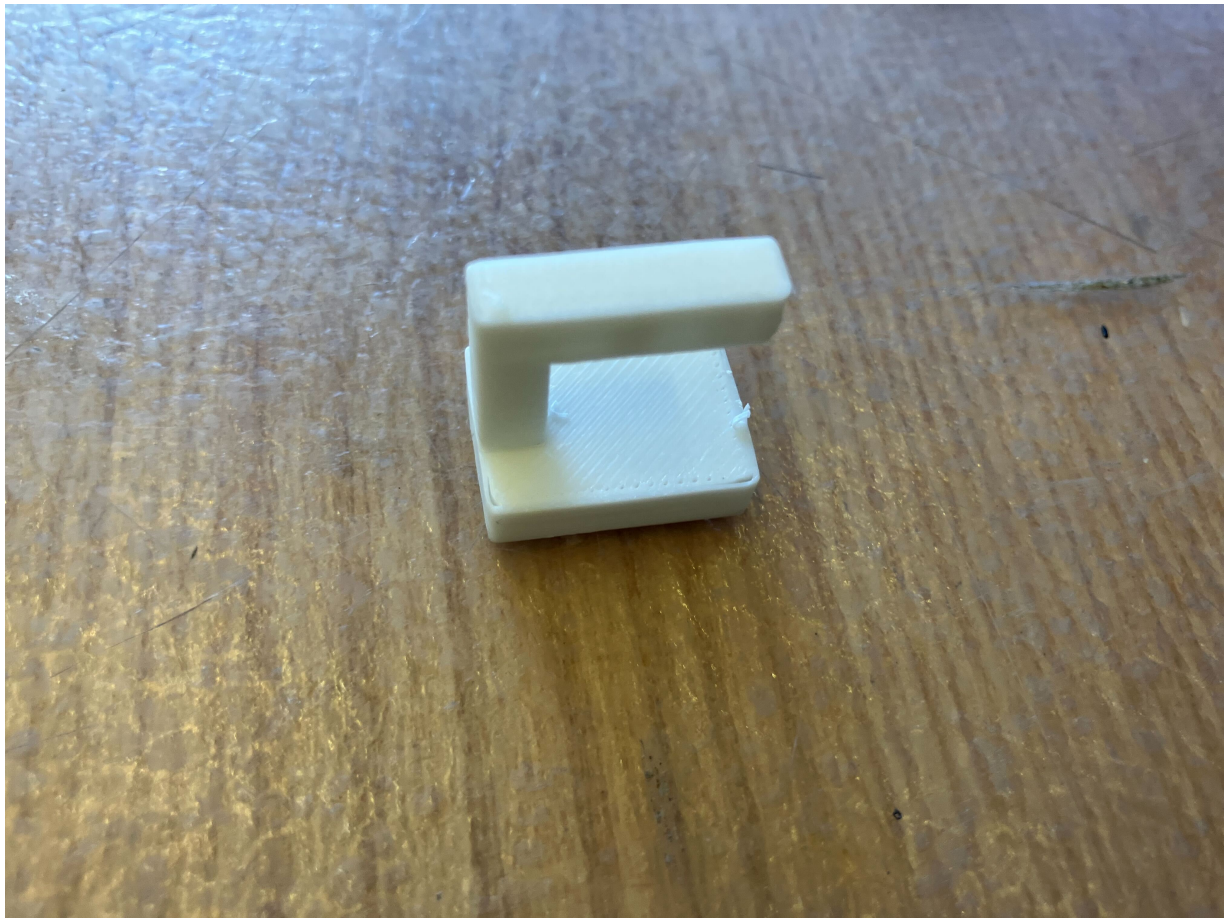
Overhang (supported)





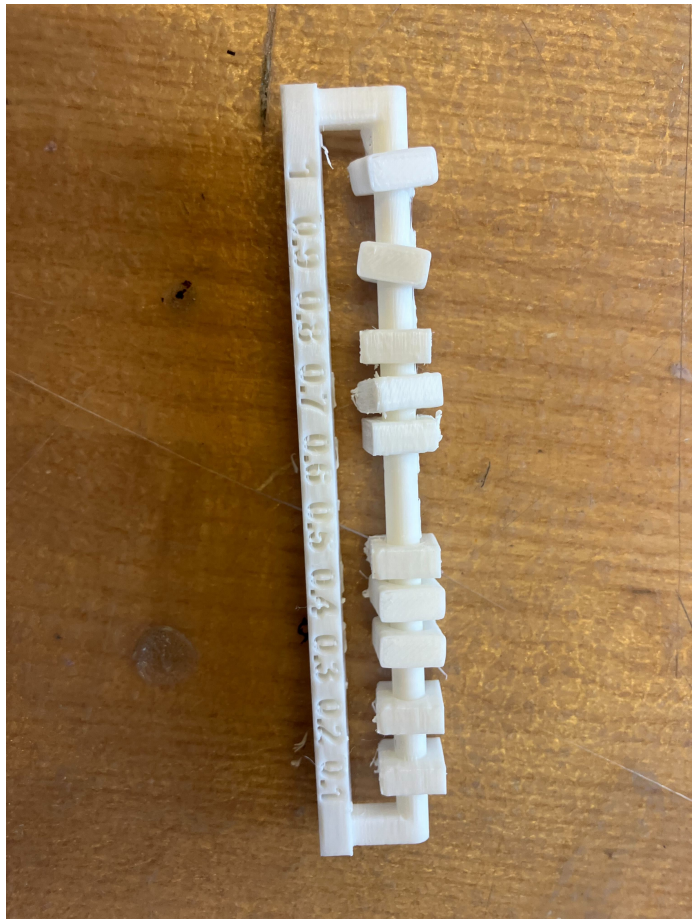


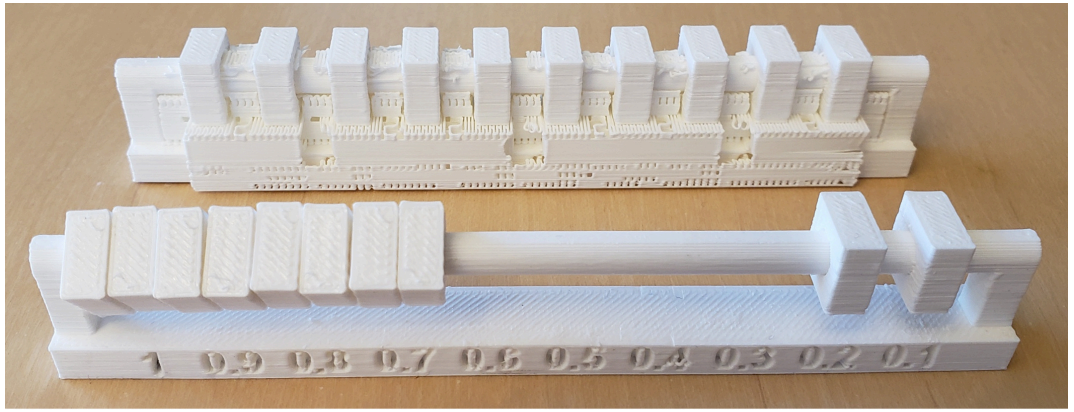
Overhang (supported)

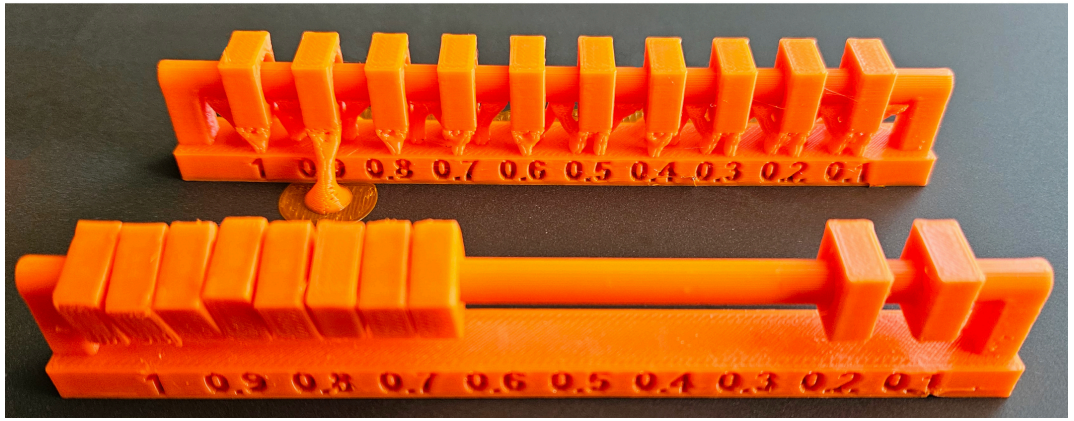


Supported right angle overhang was successful with snug support (default). We didn’t need to try organic support.

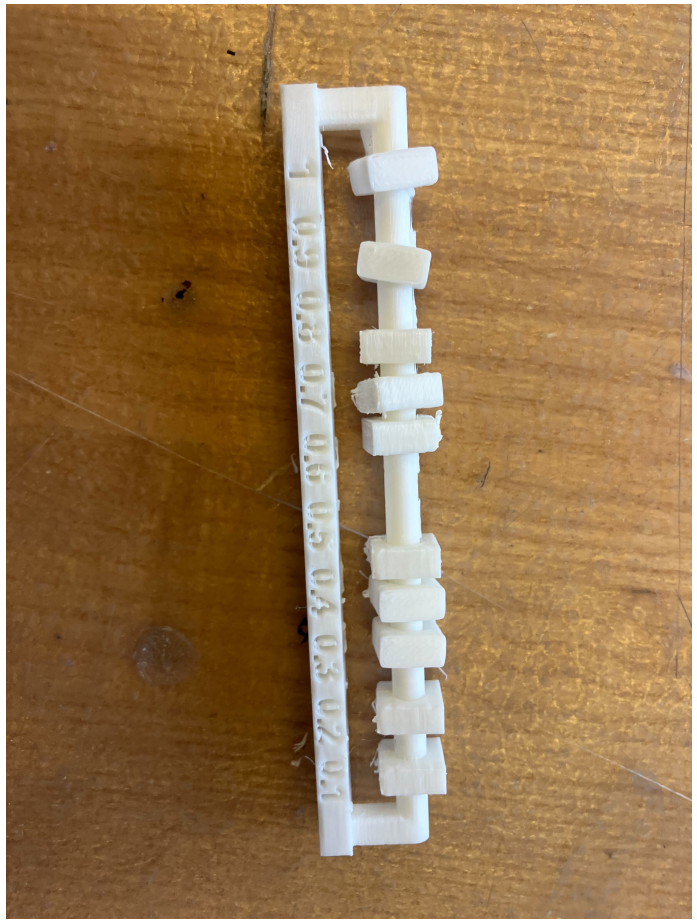
Clearance




1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1


1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1

Clearance



0.2mm is the minimum clearance for an object to be separable (tight fit, hard to rotate). Above or equal to 0.3 is looser, and below 0.2 is not separable.

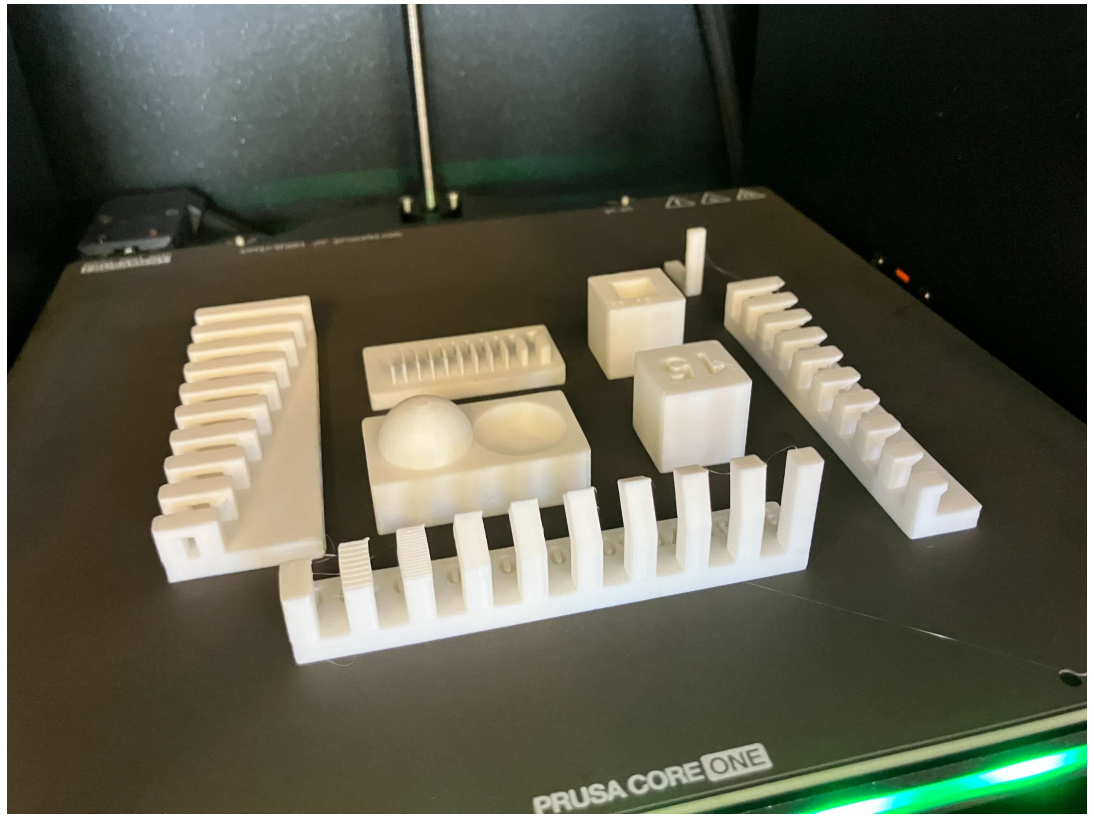
Helical support thickness (new!)

- 0.48 revolutions/mm — too fused (28 revolutions over 60mm with 6mm diameter with 2mm thickness)
- 0.35 revolutions/mm — works (21 revolutions over 60mm with 6mm diameter with 2mm thickness)

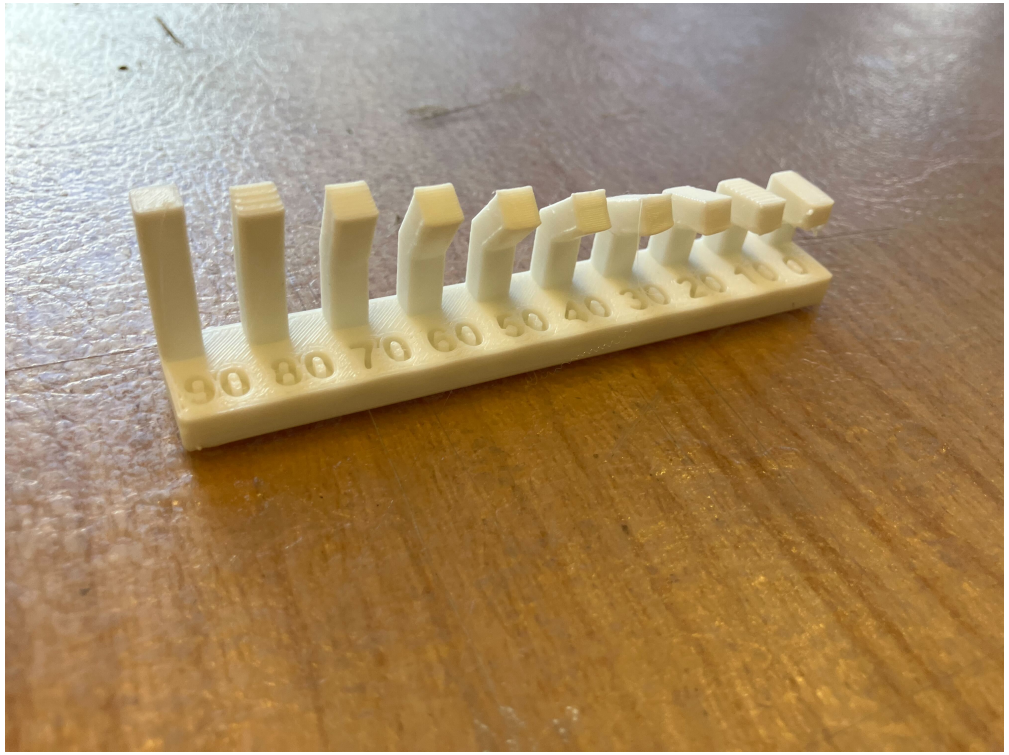
-> optimal exists between 0.35-0.48 revolutions/mm

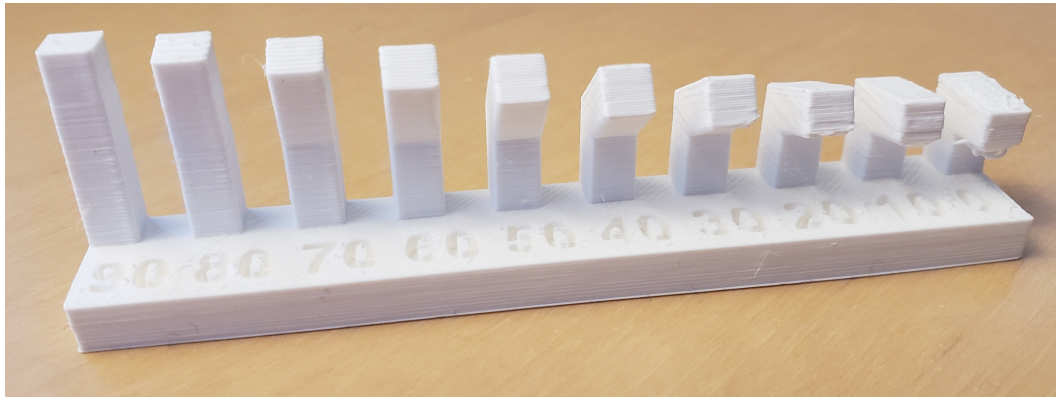
Unsupported tests

- Angle
- Overhang
- Bridging
- Wall thickness
- Dimensions
- Anisotropy/orientation
- Surface finish
- Infill

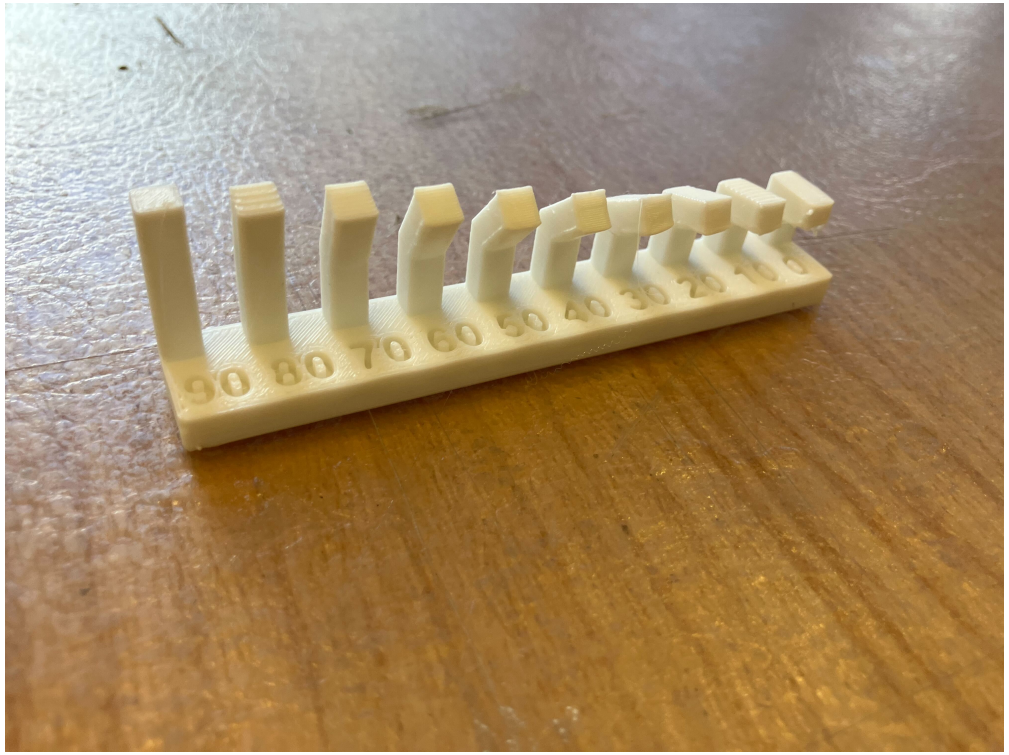


Angle



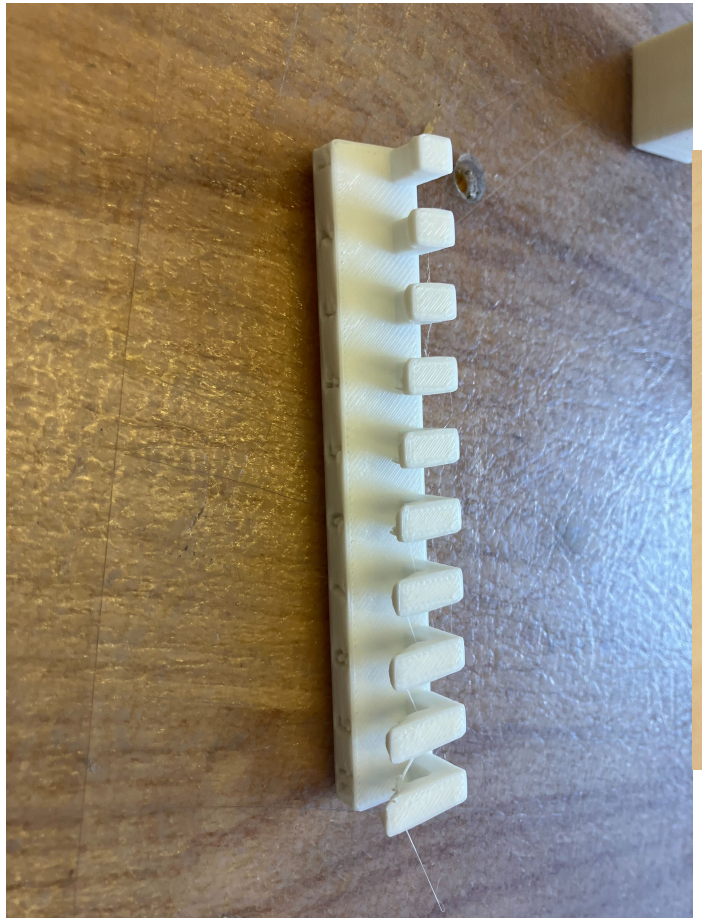


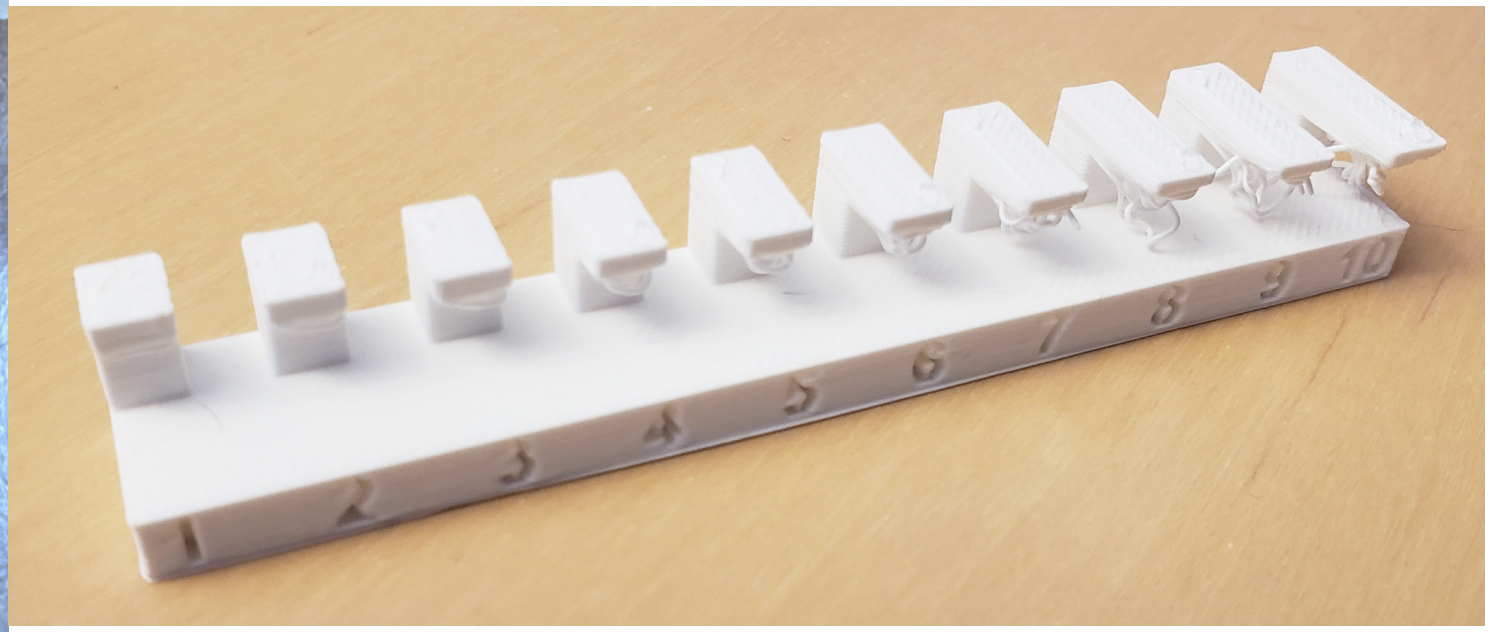
Angle



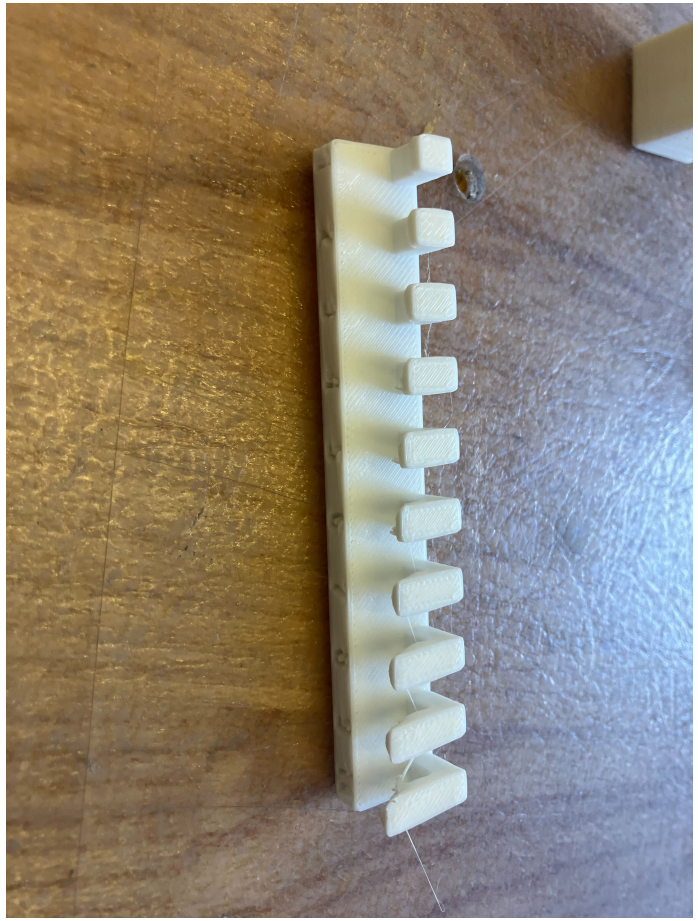
20 degrees is minimum overhang angle (defined as degrees above right angle). 30 degrees and above are nicely formed. 10 degrees and below spaghetti.

Overhang (unsupported)



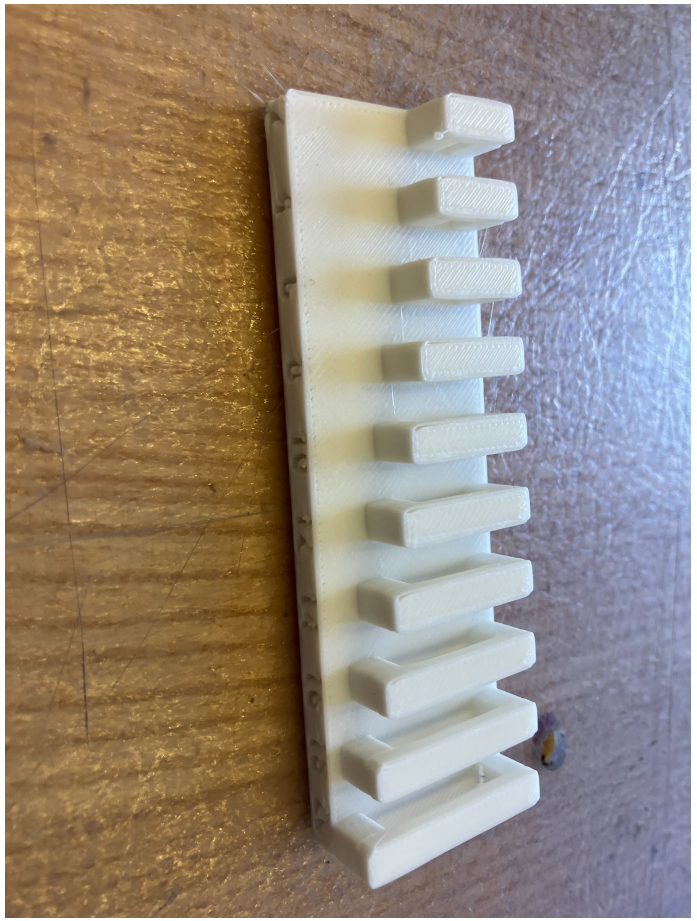


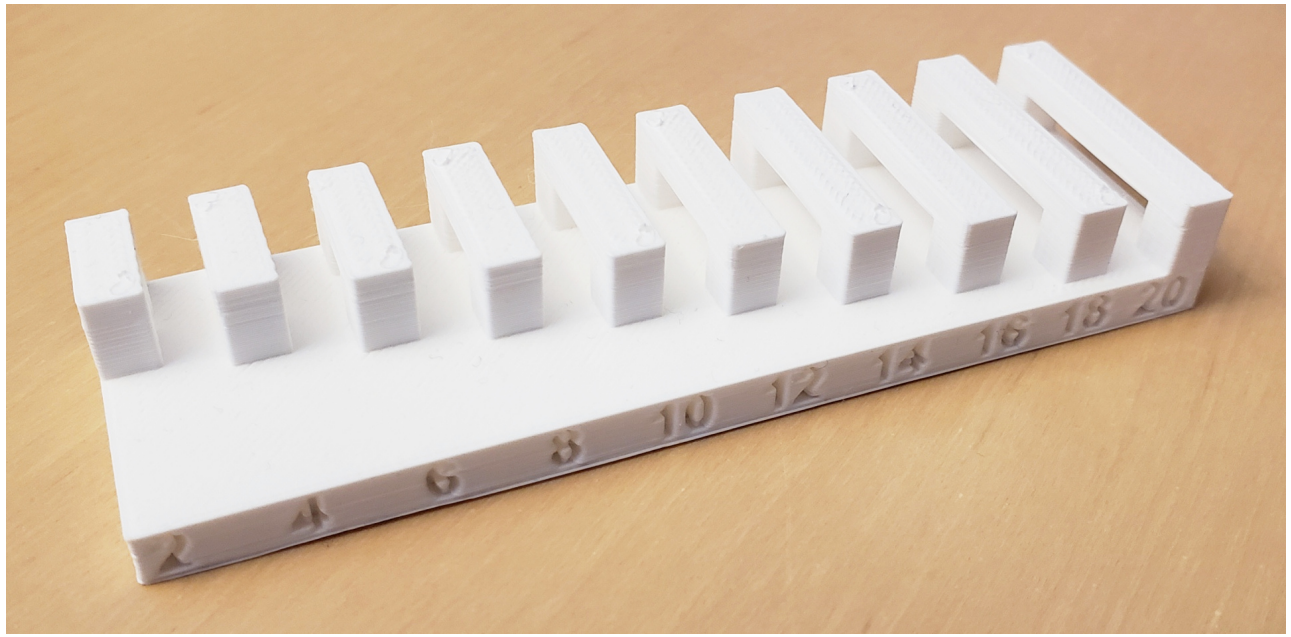
Overhang (unsupported)



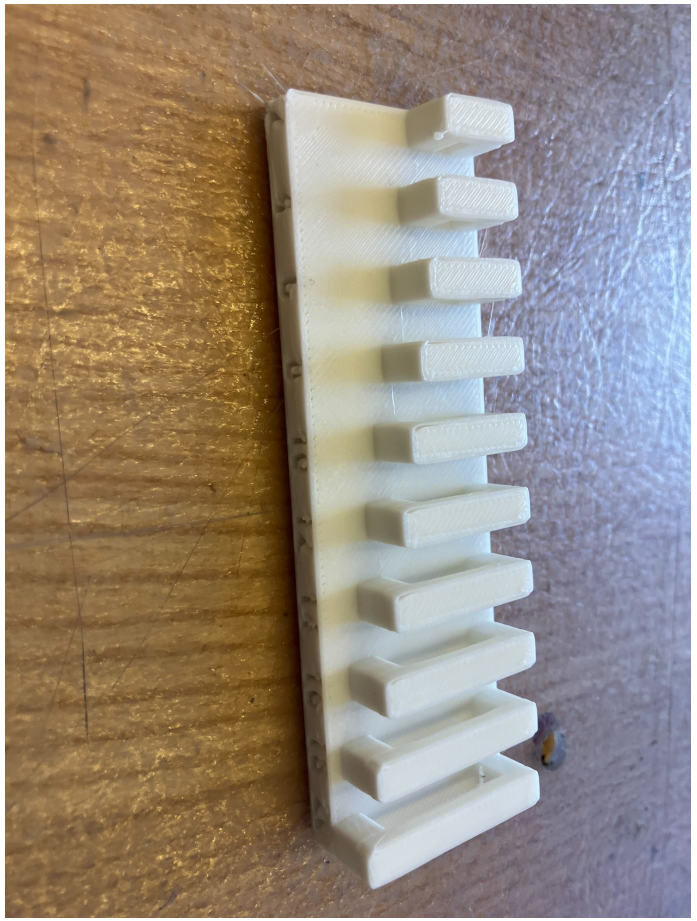
Maximum unsupported overhang distance before spaghetti is 2-3mm. Below is fine, after is awkward.

Bridging



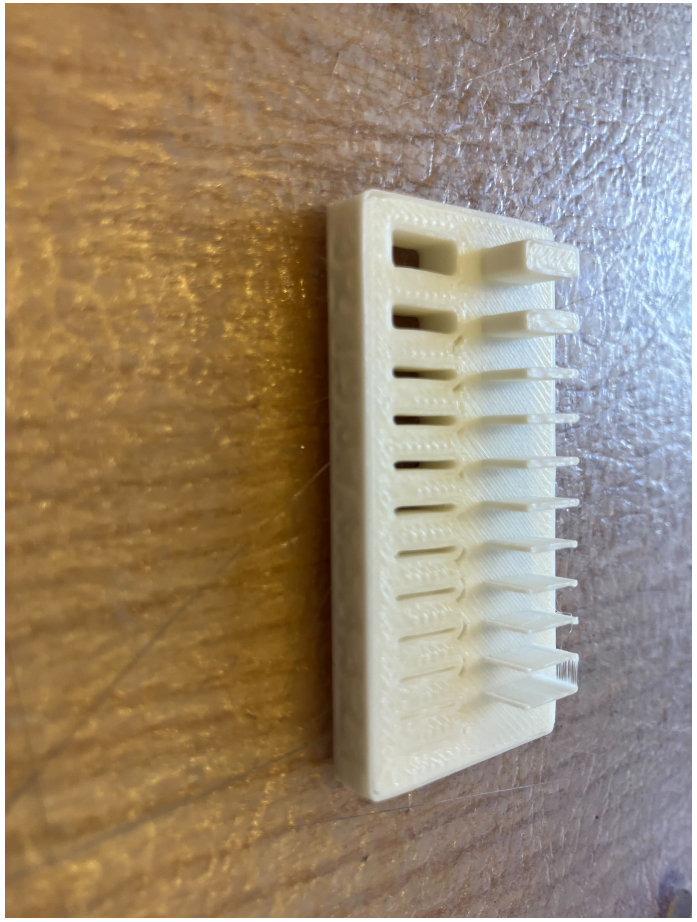


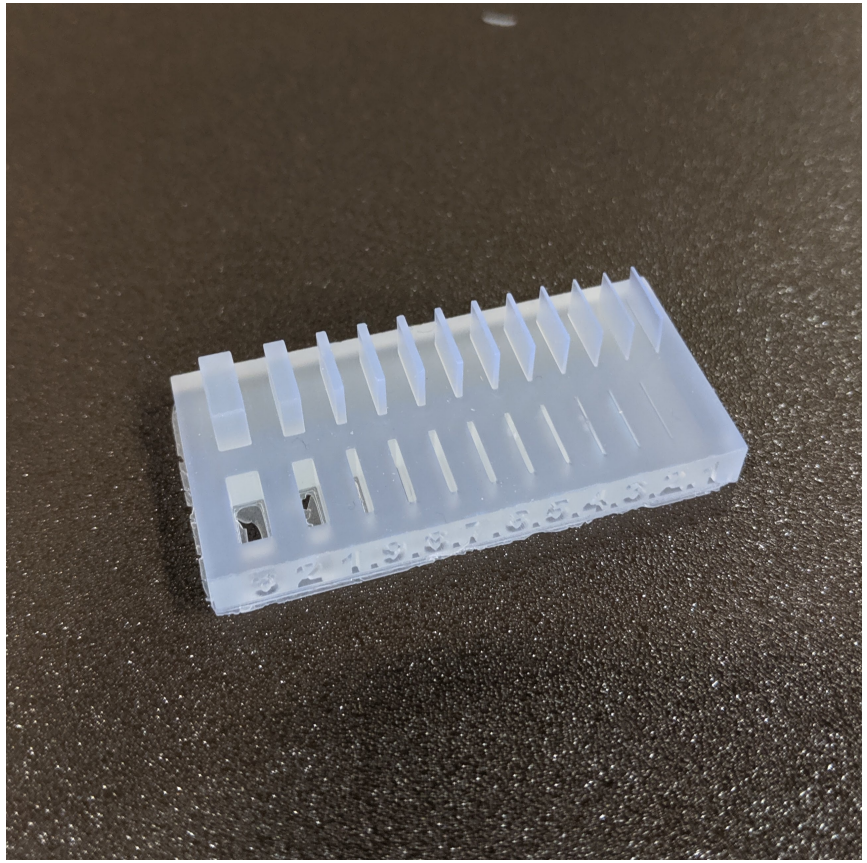
Bridging



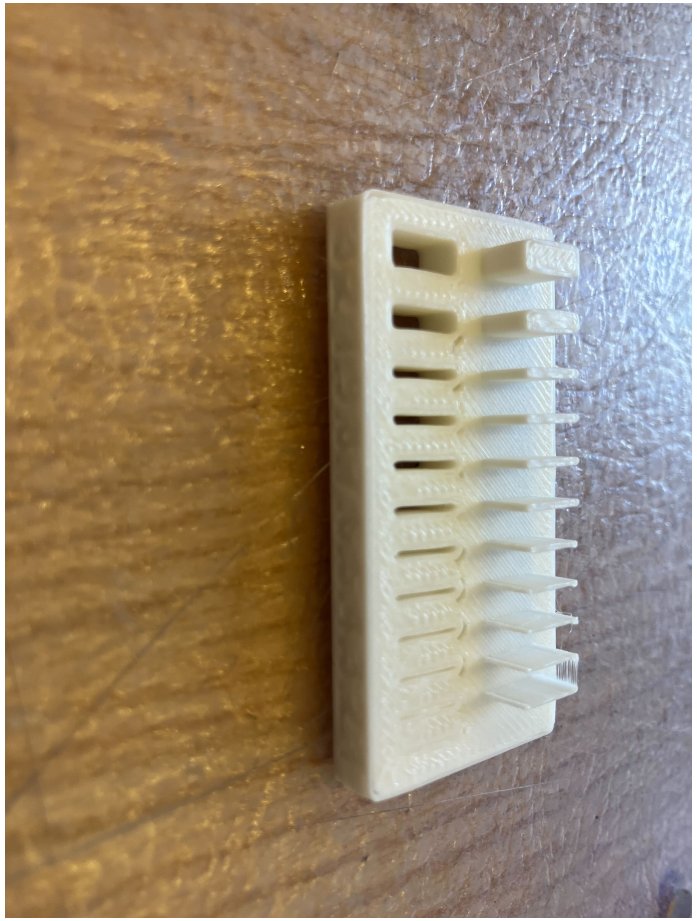
18mm is maximum bridge size. 20mm is actually not too bad.

Wall thickness



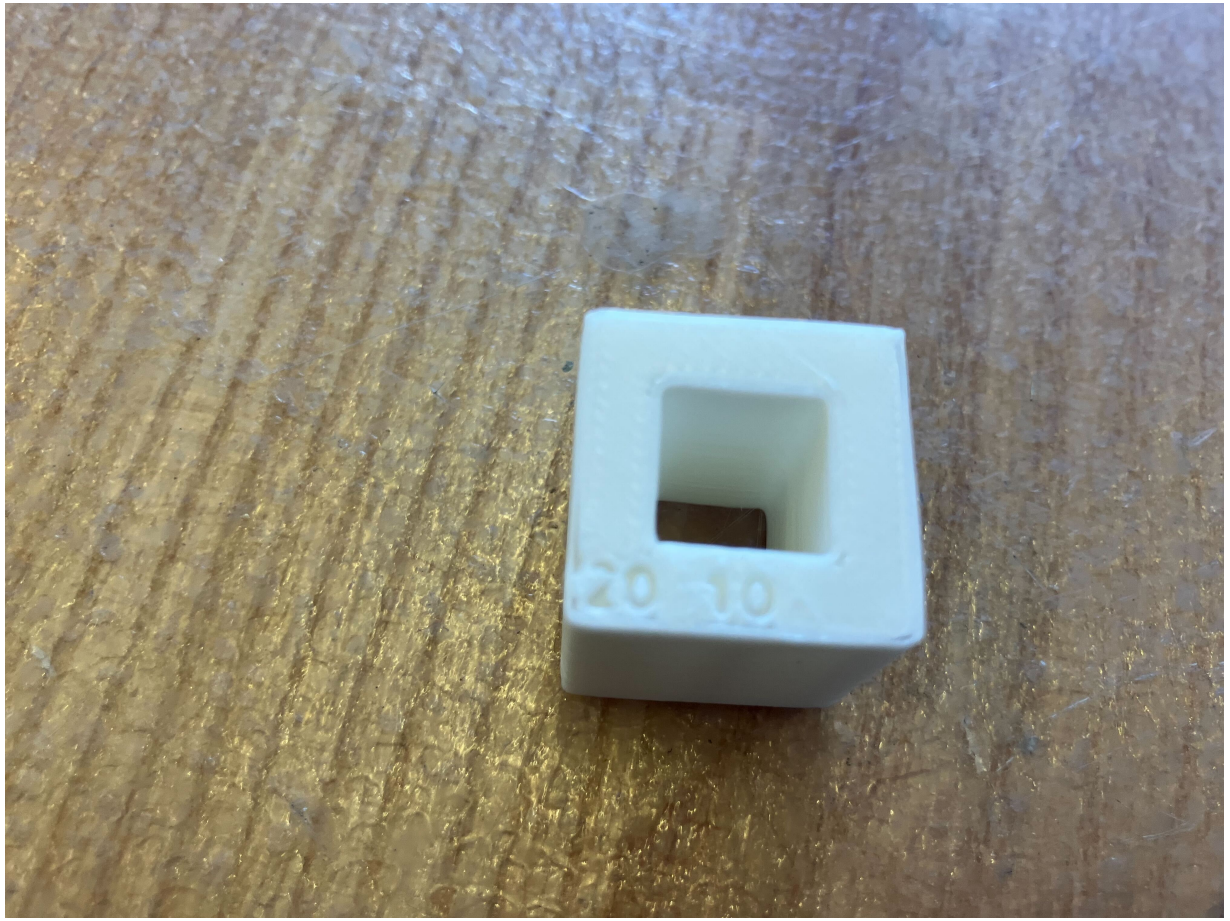


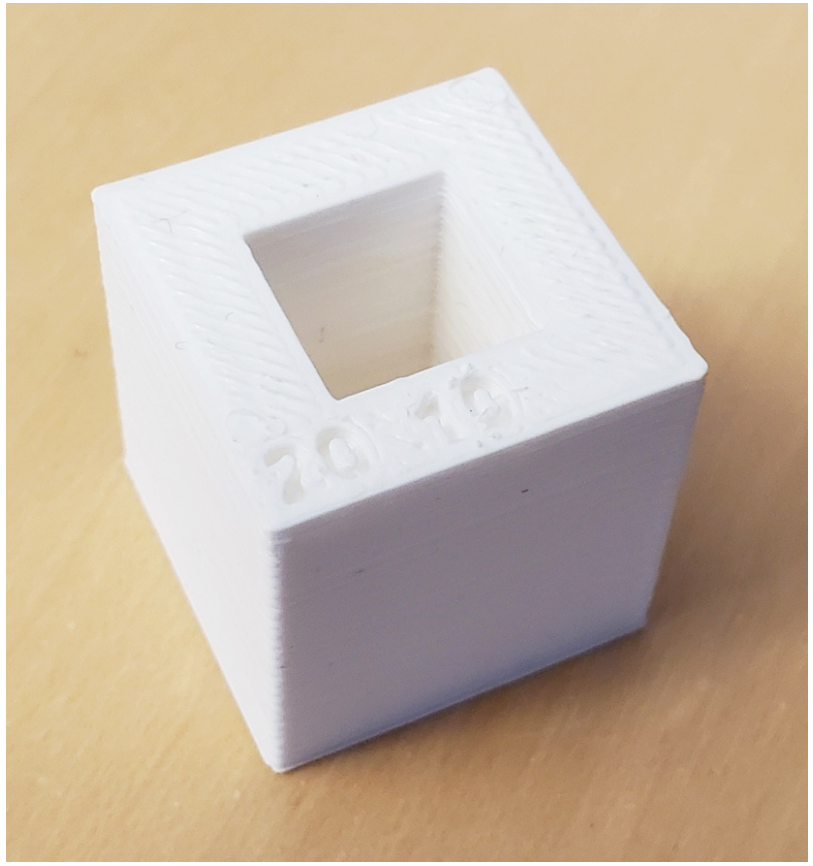
Wall thickness



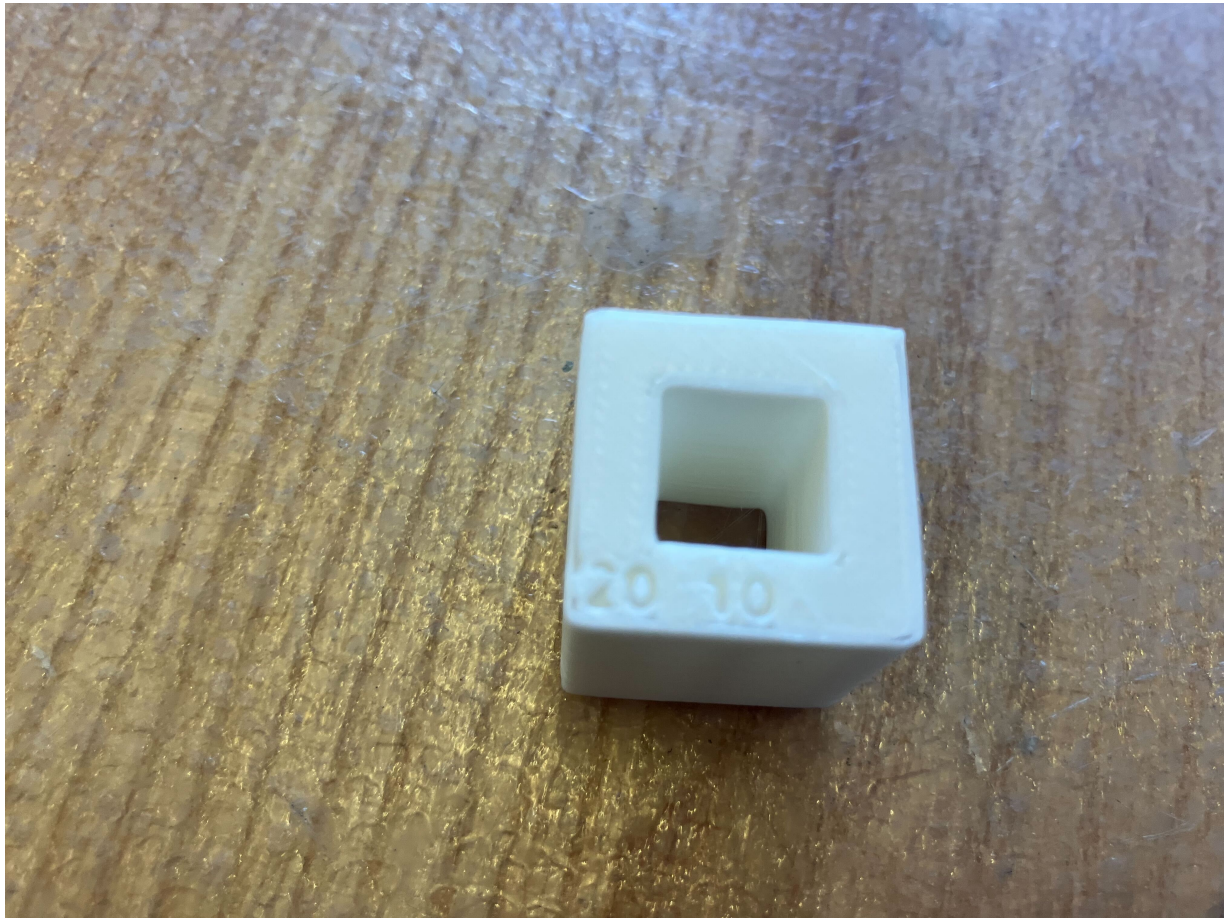
0.6mm is the minimum wall thickness that is sturdy. The rest just break off if you touch it

Dimensions



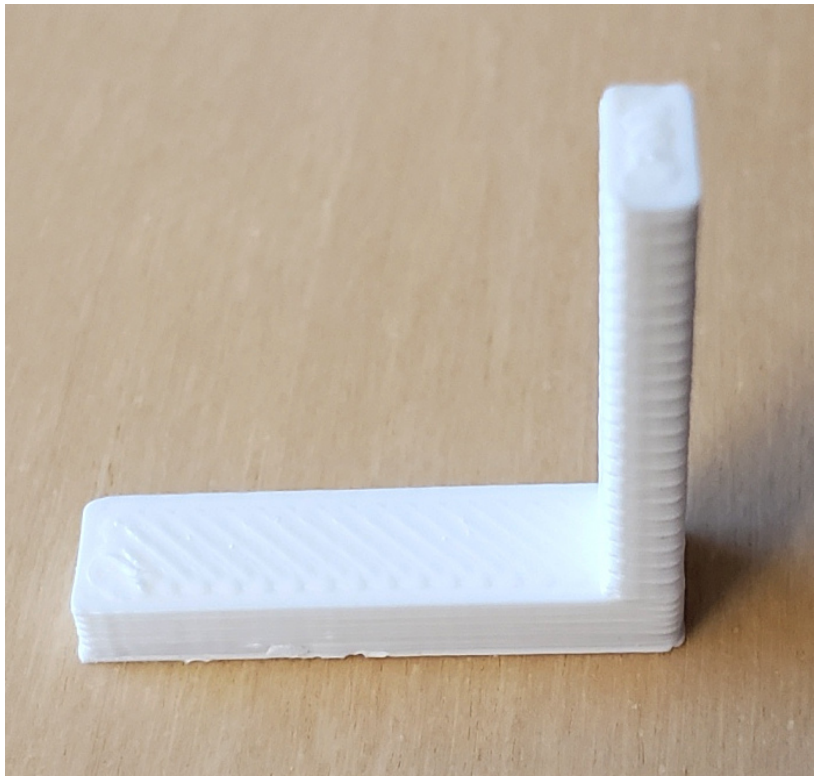


Dimensions



At the base, outer distance is 20.05 (one offset) and inner distance is 9.90mm (twice offset). Dimensions are off by 0.05mm. It actually slightly differs as a function of height.

Anisotropy/orientation



Anisotropy/orientation

Quantifying Print Anisotropy

- **Mechanical test:** Print samples in X, Y, Z orientations and measure tensile/flexural strength.
  $A = \sigma_{max} / \sigma_{min}$, $A > 1 \Rightarrow$ anisotropy

- **Geometric approximation:** Use filament width (w, XY) and layer height (h, Z).
  $A \approx w / h$

ImageJ on unsupported elbow

w= 730

h= 545

Unsupported A= 730/545 =1.339

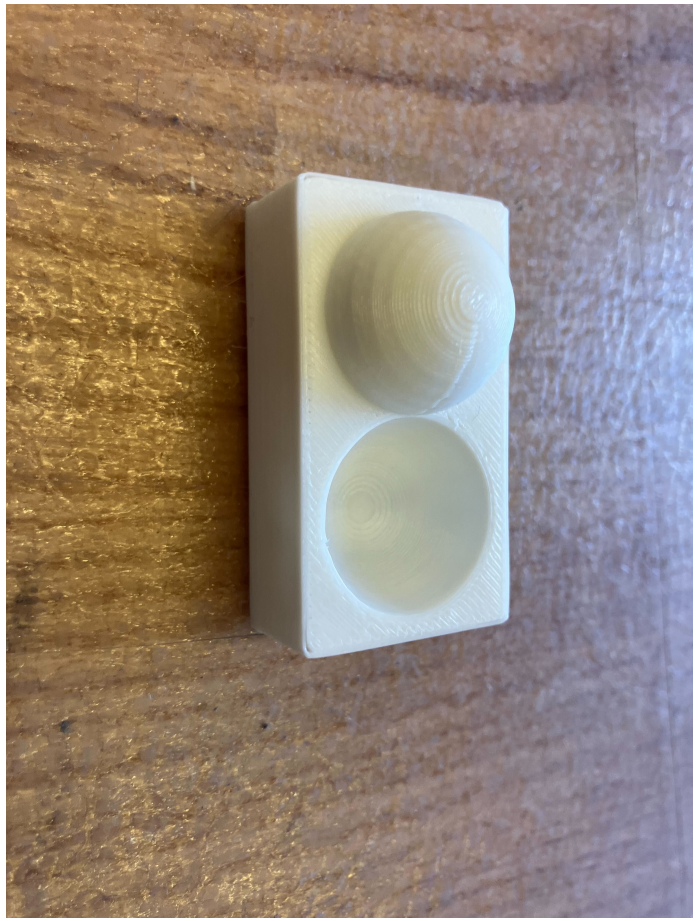
Measurements on supported elbow

h=20.16

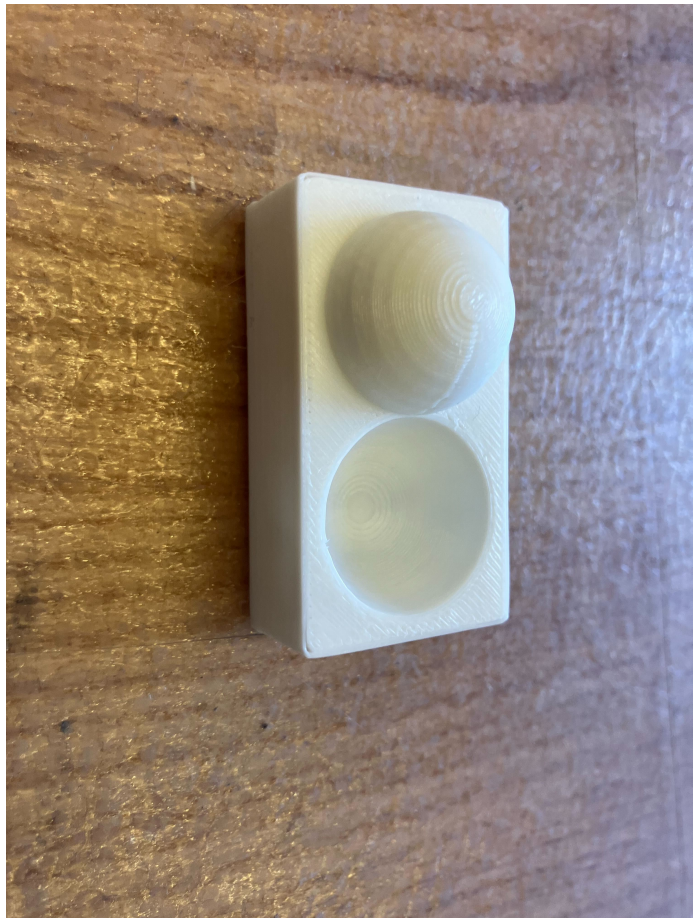
w= 20.11

Supported A= 20.11/20.16 =0.998

Surface finish



Surface finish

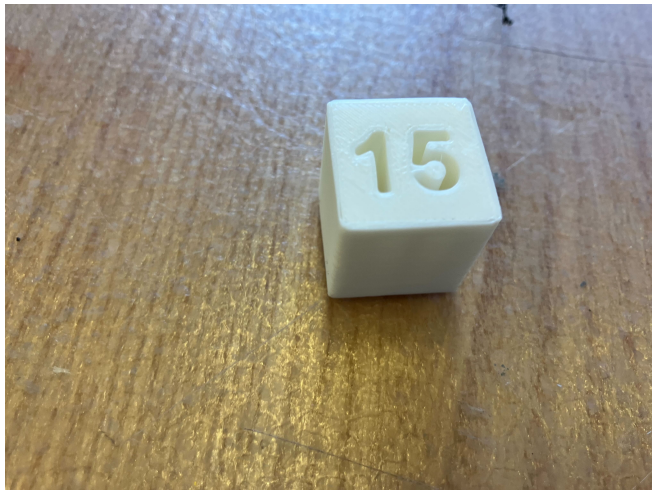


With default surface finish settings, we clearly can see the layers. Further optimization is necessary for smoothing the surface finish.

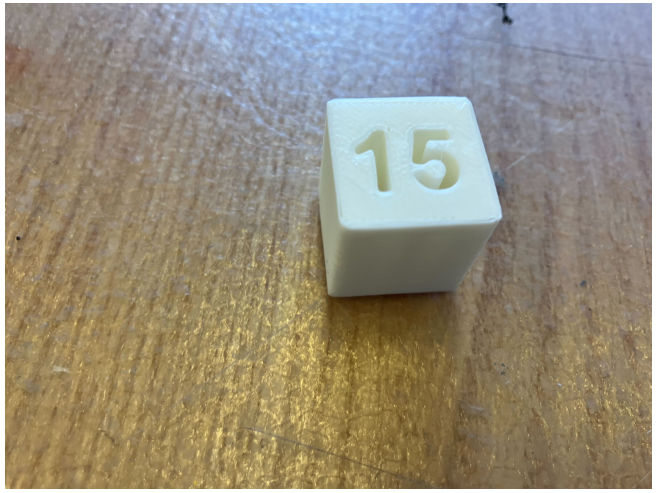
We can see the track of the nozzle during step height process. In advanced settings, the step height can be adjusted and tuned for the curvature needed.

The roundedness is limited, it’s flat at the top, which can also be adjusted from the step height.

Infill



Infill



15% infill is optimal. There is spaghetti in the interior, but very minimal.

Further characterization of other infills can be done. Higher infill is better for stiffer structures, and lower infill is better for flexible structures.

Tapers/corners

- TBD

Z offset, leveling, measurement

- TBD

Adhesion, warping, rafts, brims

- TBD

Post-processing, plating

- TBD

references

- lecture notes
- office hours insights
- week 3 course website: https://academy.cba.mit.edu/classes/scanning_printing/index.html