Building Blocks

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In this project, we were tasked with designing a **bicycle crank**

Factor of safety of 1.0

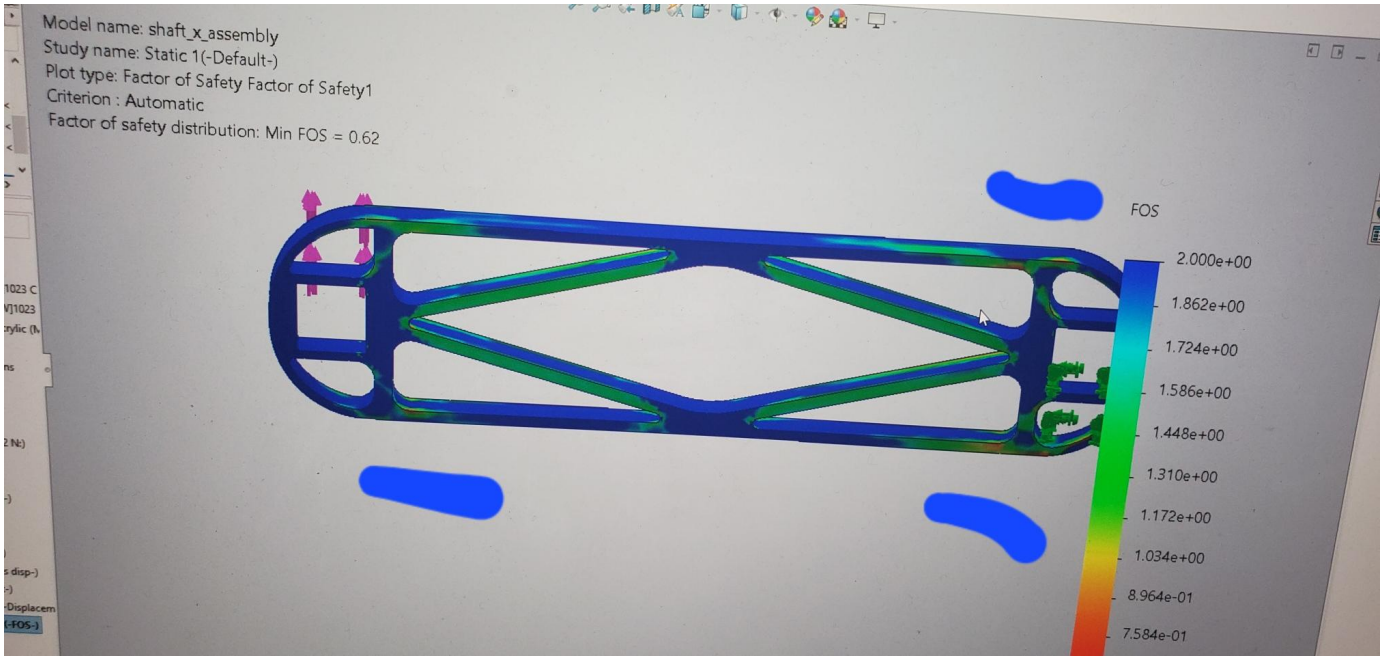
Deceleration force of 12 Newtons.

Ending Bike Force of 40N

Iteration 1

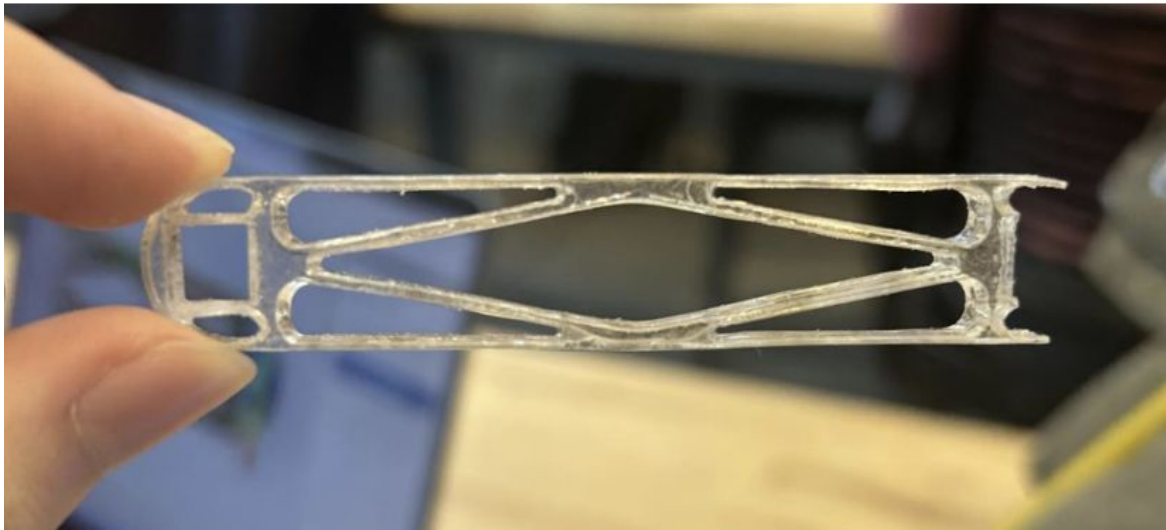
- Draw inspiration from real life bicycle cranks
- Two main beams
  - With supporting axes in the center
- Try to shave off as much space in between

Tested Result



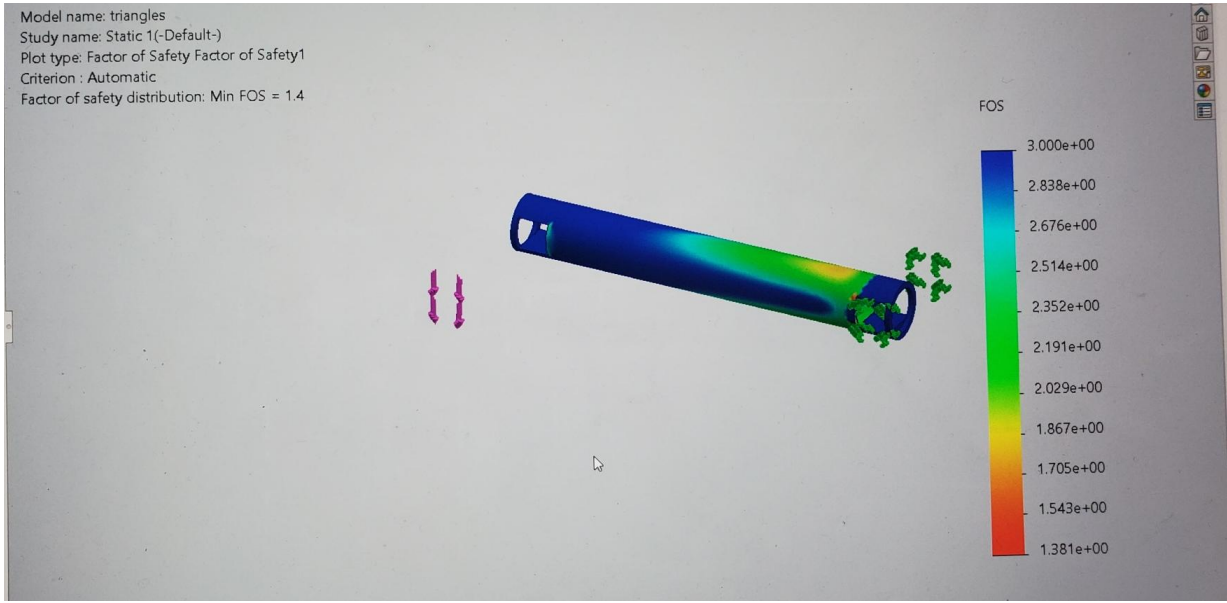
Problems Encountered

- Thin parts introduced weakness
  - Premature breakage at supports
- Realized break would occur too close to support
- Real life != CAD

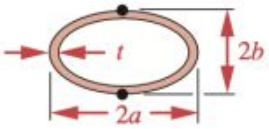


Iteration 2

- Looked to minimize torsion
- 3D printed part
  - Ring cross-section minimizes bending and torsional stress



hollow ellipse



$$Q = \frac{\pi a b^2}{2}\left[1-\left(1-\frac{t}{a}\right)^4\right]$$

radius

$r = 1.64$

−10 10

area

$\pi r^2 - \pi(r-t)^2$

$= 0.999026463842$

Moment of inertia

$J = \frac{\pi}{2}\left(r^4 - (r-t)^4\right)$

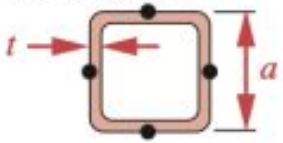
$J = 2.5281363694$

Maximum normalized stress

$\frac{r}{J}$

$= 0.648699184052$

hollow square



$$Q = 2t(a-t)^2$$

Inside corners may have higher stress if corner radius is small

side length

$s = 5.05$

−10 10

area

$s^2 - (s-t)^2$

$= 1$

"q" value

$Q = 2t(s-t)^2$

$Q = 4.9005$

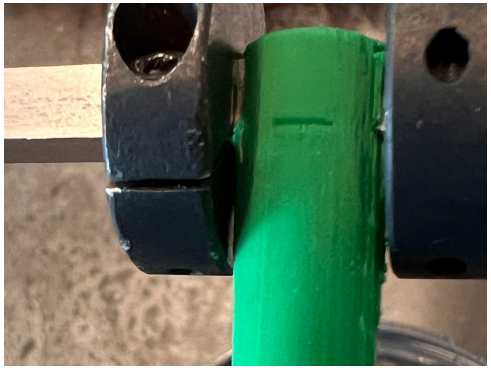
Maximum normalized stress

$\frac{1}{Q}$

$= 0.204060810121$

Problems Encountered

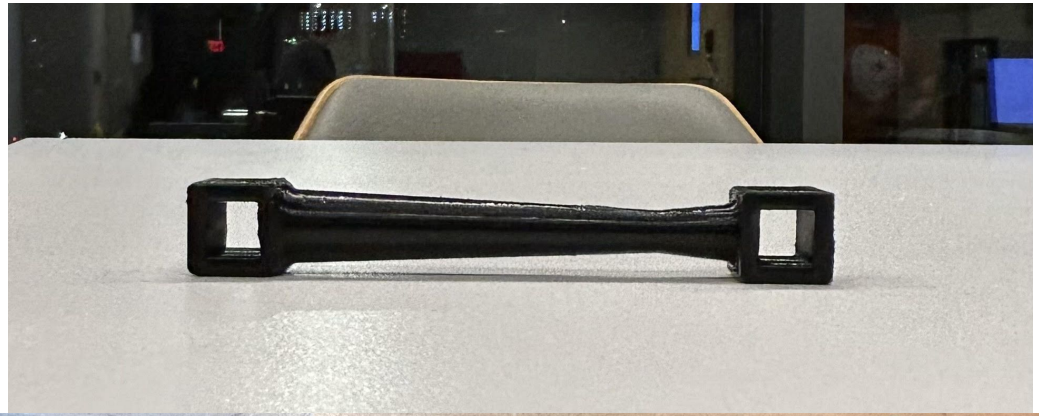
- 3D printed PLA not stiff
  - Bends under load
  - Support area not reinforced enough
  - Slight manufacturing errors, need to design around the printer



Iteration 3

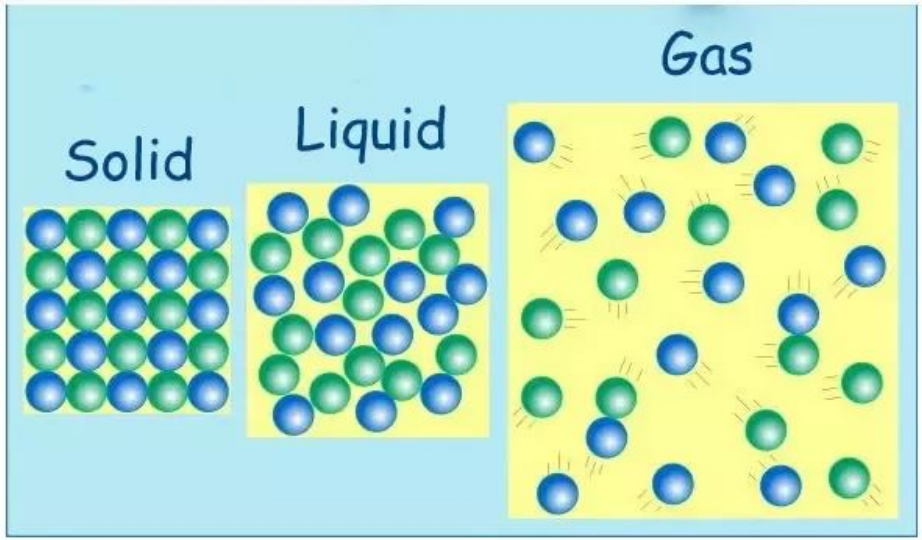
Strongly Reinforced Supports

Angle The Beam

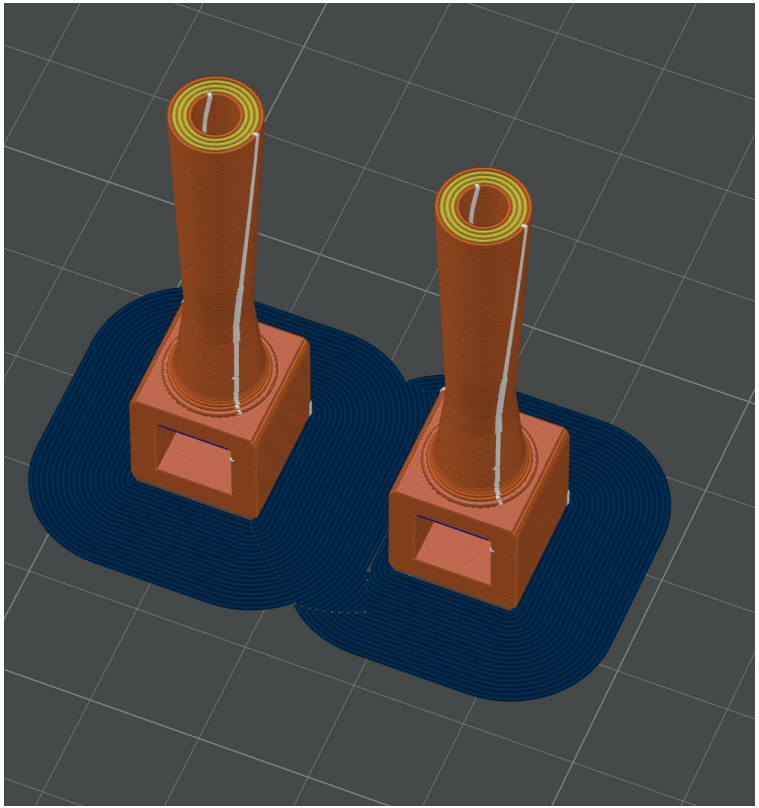


Change 3D Print Direction

Increase layer cooling time 3d printing Time



Heat makes molecules spread out and turn into gas,
cold makes molecules squeeze together and turn liquid or solid.



Stress due to torsion (MPa)

$$D = T \cdot \frac{\frac{a}{J}}{10^6}$$

$D = 35.9084533511$

$$J = \frac{\pi}{2}\left((a+d)^4 - a^4\right)$$

$J = 9.6249759526 \times 10^{-11}$

$d = .001$

−10 10

$a = .00195$

−10 10

$a + d$

$= 0.00295$

$T = 40 \cdot .04431$

$T = 1.7724$

Stress due to bending (MPa)

$$t = \frac{\frac{Nx(a+d)}{\frac{\pi}{4}(a+d)^4 - \frac{\pi}{4}a^4}}{10^6}$$

$l = .0701$

−10 10

$l_1 = \frac{l}{2}$

$l_1 = 0.03505$

$N = 40$

−10 40

Ductile Yield (MPa)

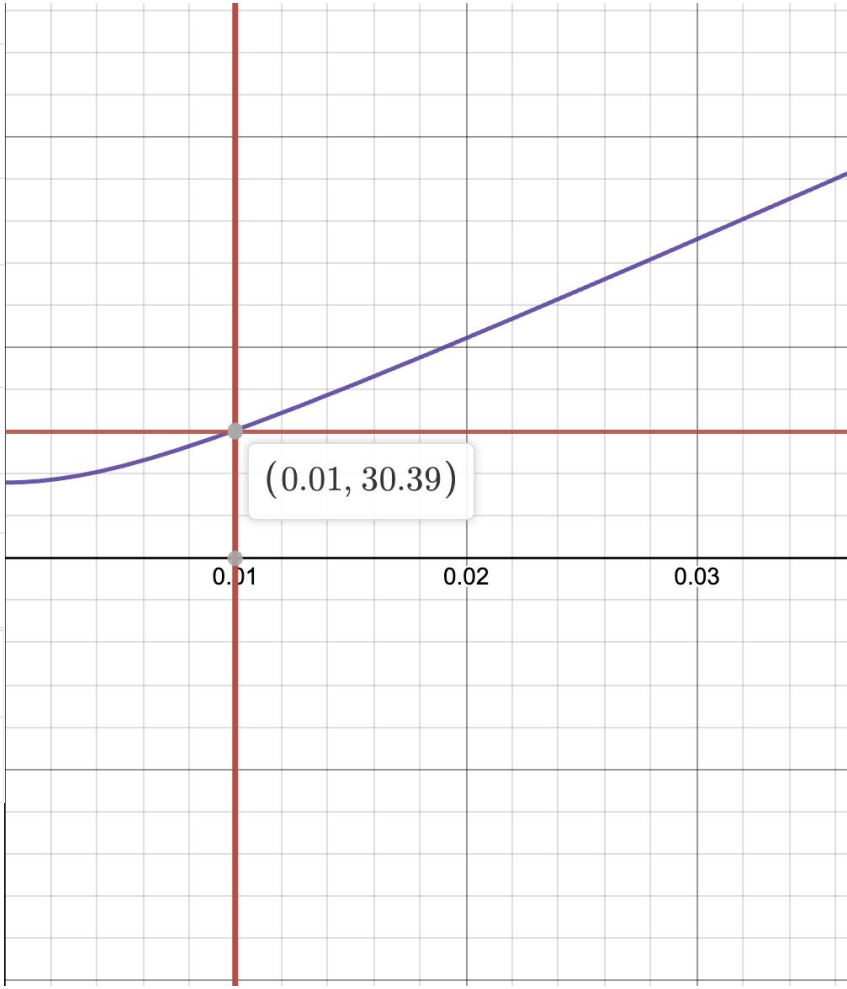
$$\sqrt{\frac{D^2}{4} + t^2}$$

$x = .01$

−10 10

$y = 30$

−10 30



The Math:

Testing and Conclusions

- Clean break at 8+ pounds (Ductile failure appearing as Brittle)
- 5.2 gram weight
- 50+ iterations

Thank You!