Unicycle Project
Lester Vecsey

1 Overview

Design a unicycle that is for the most part 3d printed. It is split into pieces so that you don't really require a large format printer.

Some parts can be made from carbon fiber, such as structurally for sections of the wheel, with more of a plastic for the tire.

Bearings are ceramic and are sized to be from a skateboard / inline skating.

There are also some extra features that can be added such as an onboard Raspberry Pi, Lithium Ion battery cells around the seat post, and a speed sensor.

2 Software

Here is a brief list of software used throughout the progression of this project.

2.1 Modeling

- Autodesk Fusion 360
- **OpenSCAD**
- Triangle / trimesh or custom programs generating .stl

2.2 Visualization

- **Povray** for visualization
- meshlab

2.3 Slicing

Cura, and slic3r.

3 Workflow

In general the workflow is to model the parts, export .stl files, and then slice these files into .gcode.

4 Item breakdown

Certain components are purchased ready made, however in a later iteration some of them could also be customized as 3d prints too.

- CNC machined downhill mountain bike **pedals** (left, and right threaded)
- **Unicycle seat**, with optional front handle or grip.
- **Bearings** (ceramic)
- **Metric fasteners** for assembly, such as M5 screws.

Printable parts

- Axle with barriers or dividers for where the bearings are placed.
- Two large discs or plates with holes punched out of them that are fixed to axle, forming central region of wheel.
- Non-standard cranks which are just fastened or attached to the axle.
- Collet style left, right clamp around the bearings, extended into a frame.
- A triple clamp type of piece at the top of the two side frames
- Seat post stem, optionally modeled to support lithium ion cells.
- Central rods (4) that interconnect and support the plates.
- 12 sectional pieces of the wheel and tire, printed from dual filament.

Ideally the Axle, and two large plates could be printed as a single joined part.

That leaves 6 remaining types of parts to print.

5 Assembly

Begin with the unified axis / plate unit.

Slide on the bearings, collet clamps (frame sides), and cranks.

Place a metric fastener into each collect clamp, tighten it and torque it down.

Attach the triple tree, and seat post stem.

Screw on and torque down the standard sized mountain bike pedals.

Attach the fancy carbon fiber seat.

6 Bill of Materials (BOM)

Description	Store	Price (USD)
CXWXC Sealed Bearing Mountain Bike Pedals Flat Platform Bicycle Pedals CNC Aluminum Alloy BMX City	AliExpress	23.80
Exceed Carbon Unicycle Saddle - Black	Unicycle.com	250.00
Size: 8mm x 22mm x 7mm (Inner x Outer x Thickness) black ceramic bearings	Amazon.com	12.90
Metric fasteners (assortment) M2.5, M3, M4, M5, etc.	Amazon.com	19.99
24 additional M8 bolts for wheel, length is 20mm		

Tax not specified. The pedals from AliExpress have a shipping fee, and the unicycle seat has a shipping fee.

7 Prototype images

7.1 Current

Another idea is to use **Meshlab** software to pattern each quad face with some fractal terrain.
This is shown already in this preview of an assembly picture.

7.1.1 Outer frame

7.1.2 Receiver hub

7.2 Prototype models

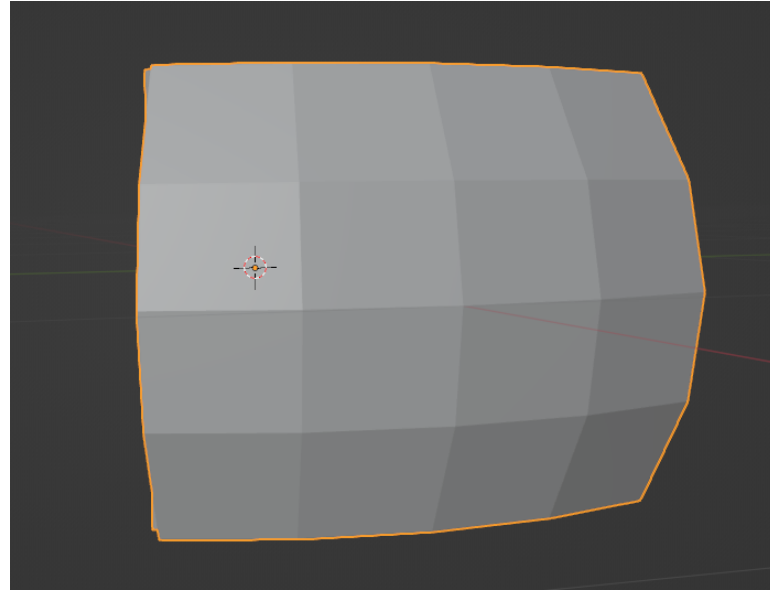The prototype is for a 24" wheel with a 3" tire.

Figure 1: Screenshot showing the locations on which additional pedal threads can be placed. One would be a standard crank length of at or near say 170mm, and the rest are slight variations. A total of 16 threaded holes, each to be positioned on the center of a flat face.
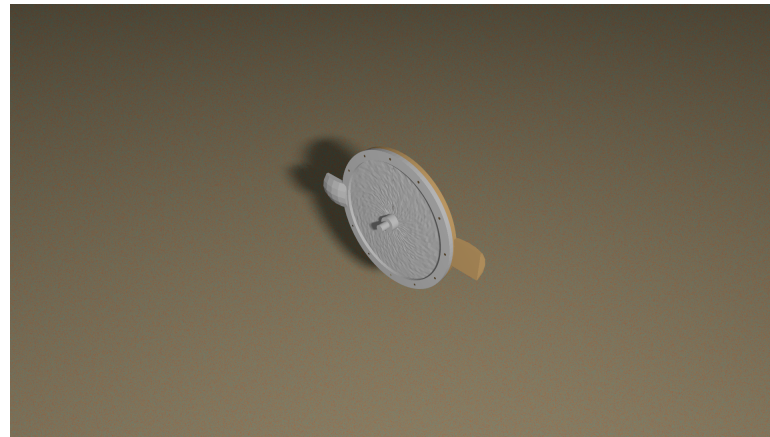

Figure 2: Screenshot showing left and right pedal blocks, each with multiple threads. The left hub is identified in grey and the right one is gold. 12 threaded holes surround the edge of these hub plates, and are used for the rest of the wheel which is in sections.
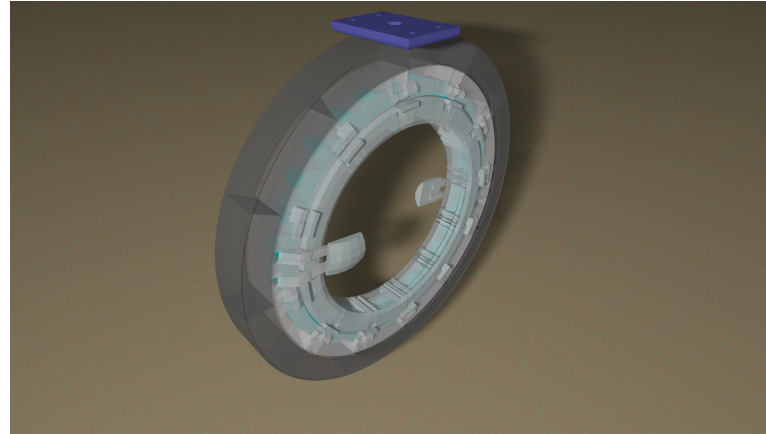
Figure 3: Design has progressed to an outer bearing concept, with 29 inner rollers. The pedals are shown visually however aren't connected to a sectional piece just yet.

These are .STL files for use with your slicer such as Cura, etc.

unicycle_stlpack.zip

7.3   Test parts

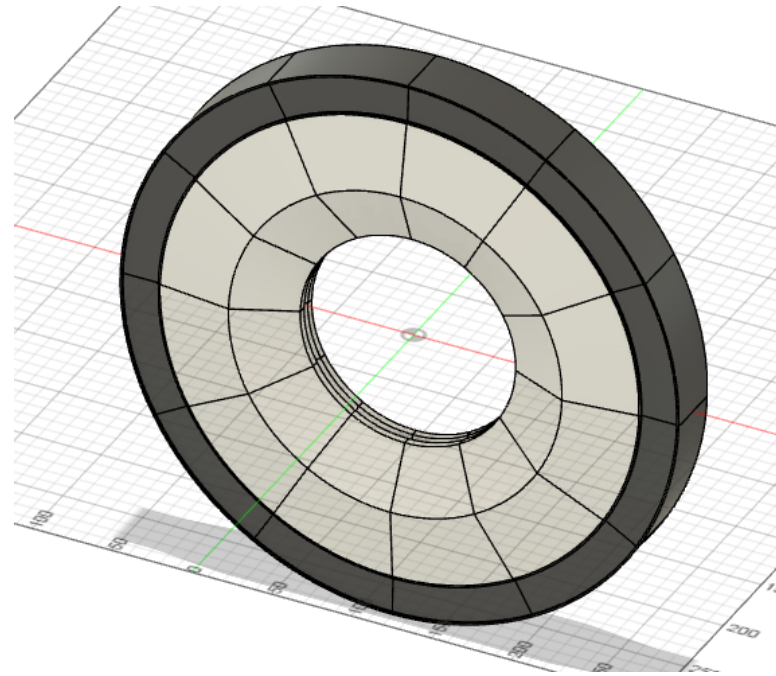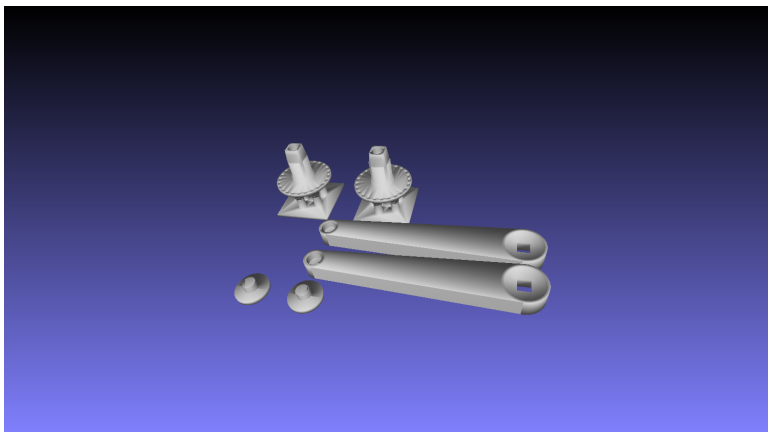Rim section (30 degree part), 1 of 12. It has a ball and socket, as a **snap fit** part.

Figure 4: Wheel sections with the tire assembly complete, and the rest of the cross sectional area (Grey) in need of holes, and threads.

7.4   Assembly
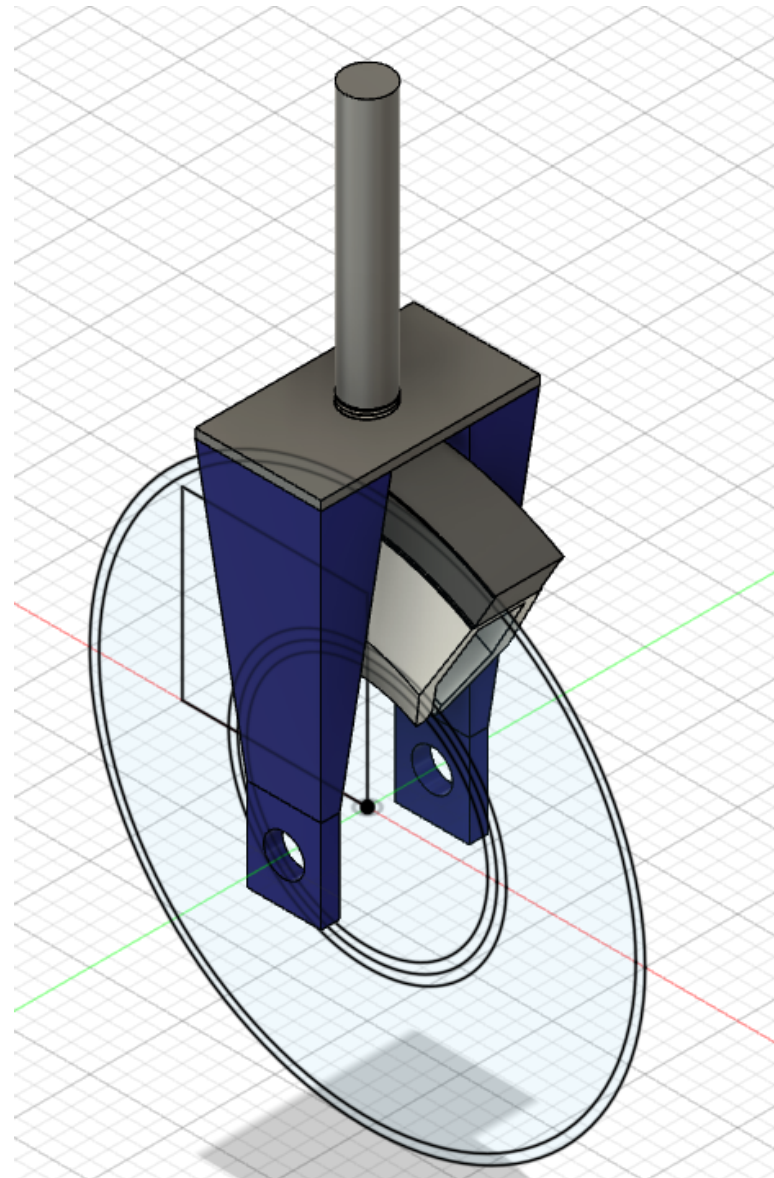
Figure 5: Draft view of the possible side frames, triple clamp, and seat post. The cross sectional piece here is accurately modelled, just missing some screw attachment points.

Figure 6: Sketch with estimated measurements for the triple clamp, showing M8 screw holes and a center thread about 1" in diameter
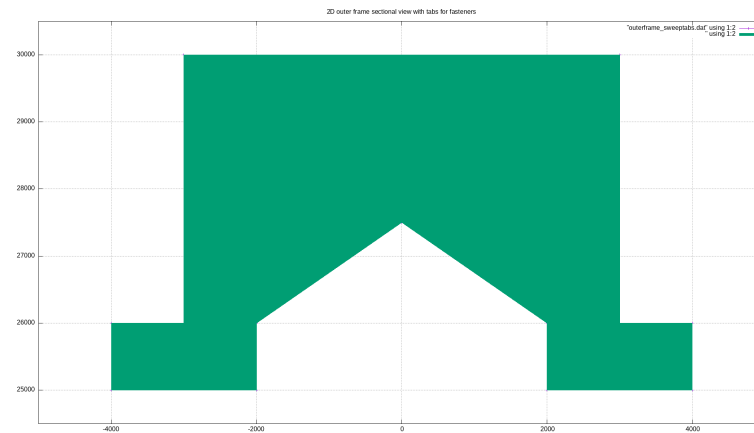

Figure 7: Sectional 2D view of outer rim section, for a revolve operation

assembly.stl snapshot with meshlab showing an assortment of parts (hub split in two, cranks for mounting mountain bike pedals, and the attachment screws for each crank)
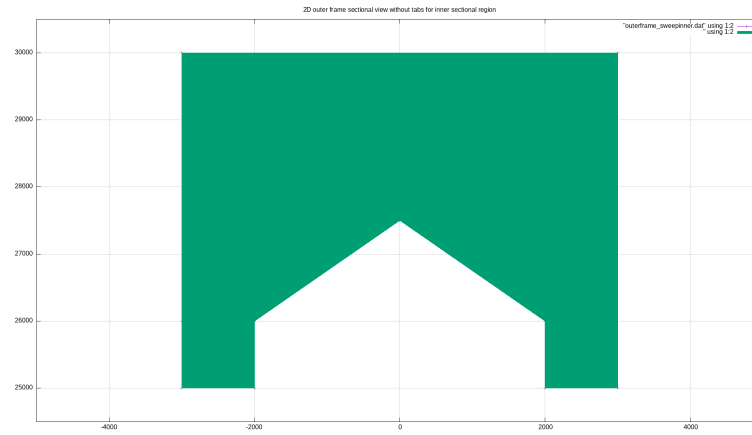
Figure 8: The middle 20 degree region of the cross section piece. The tabs are gone here because the screw bolts need to be accessible.
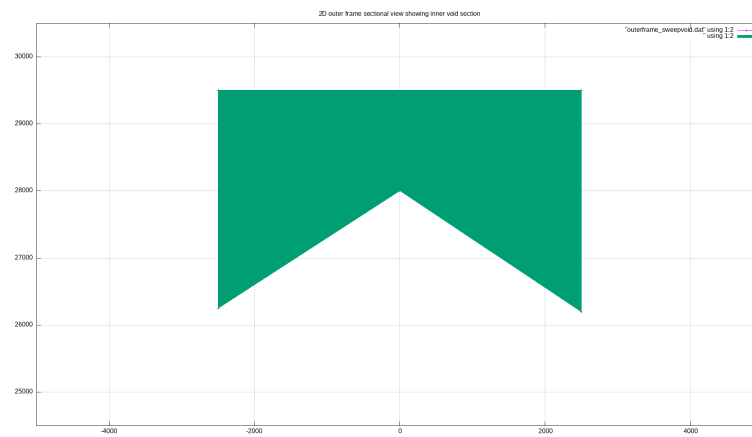

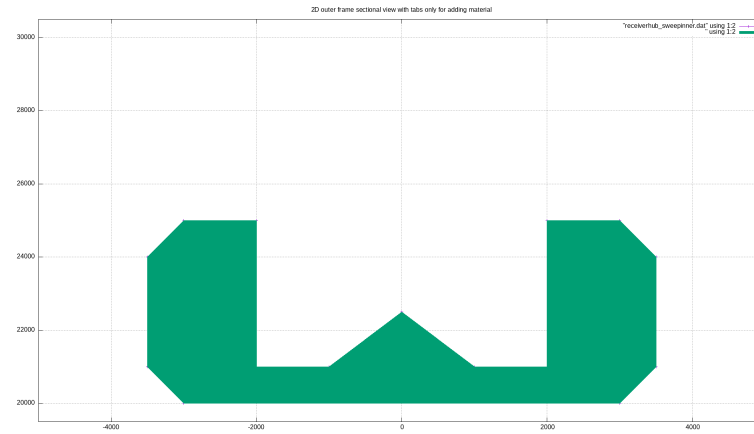Figure 9: Inner void section also for revolve, used as a tool to remove material

Figure 10: Inner section of receiver hub, representing the cross section that doesn't have any mounting tabs on it for metric bolts
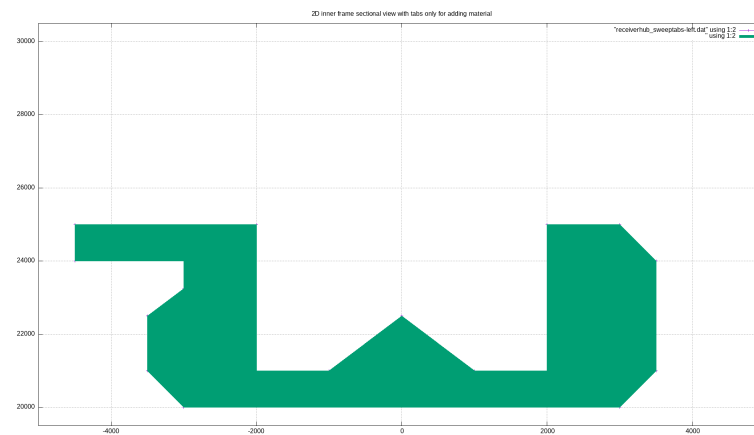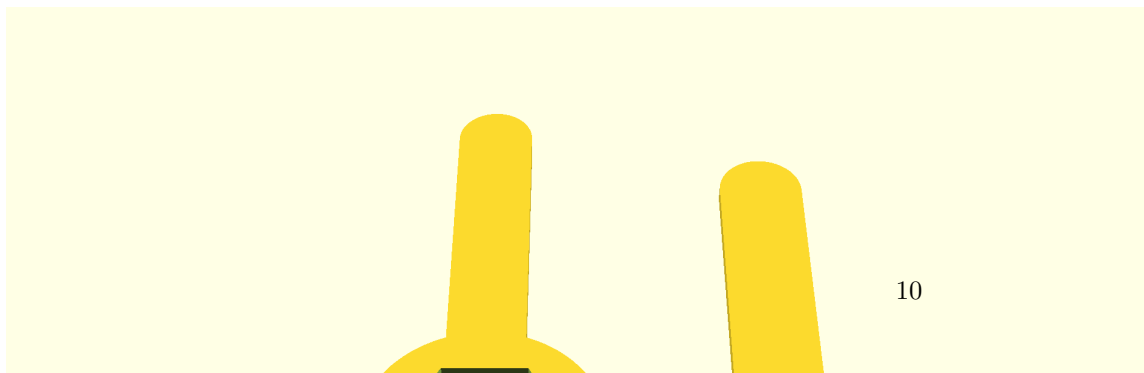

Figure 11: Inner section of receiver hub, including a left tab. This is used for a staggered mounting tab location.

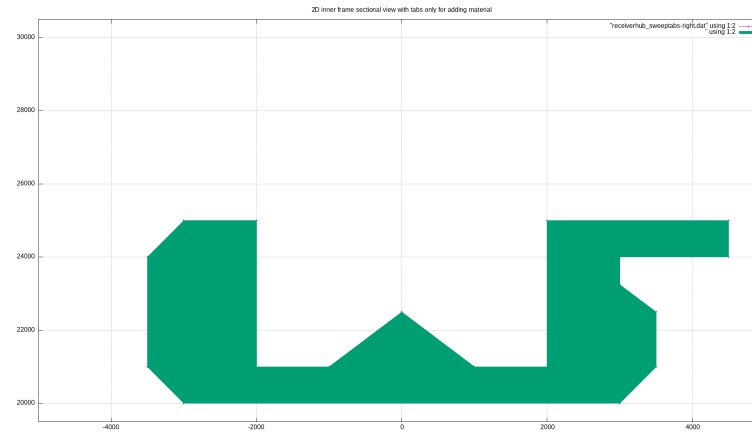## 7.5   3d printed tools for assembly

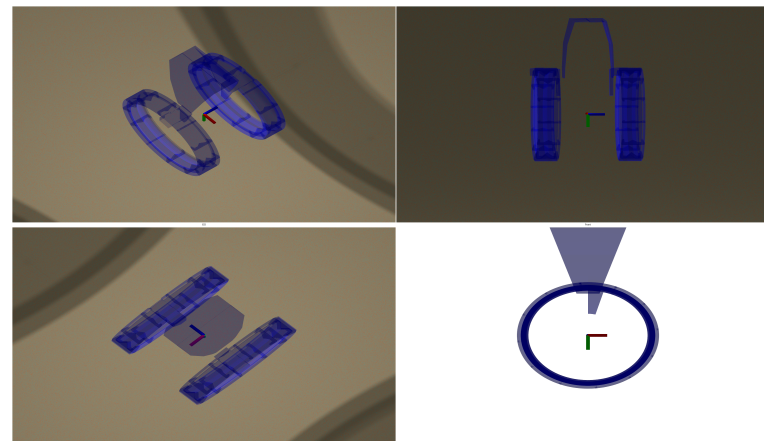Figure 12: Inner section of receiver hub, including a right tab.

Figure 13: Unicycle frame, combined views

An M30 metric fastener can be tightened with these tools, using a 22mm hex allen and also around the external hex shape of the bolt.

Other tools to be used will be 6mm allen (possibly 8mm allen), and perhaps a 3d printed adjustable wrench.
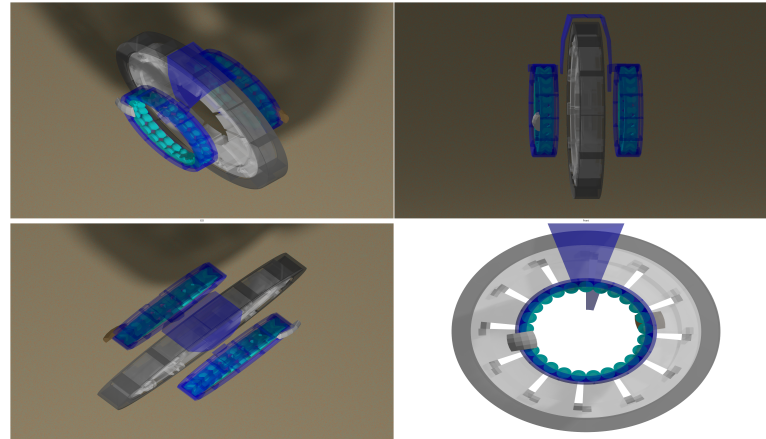
Figure 14: Unicycle assembly, combined views

7.6 Actual parts

Crank with threads for attaching mountain bike pedals.

Hub (split in two, can be mated together currently with 4 small bolts)

7.7 Print times

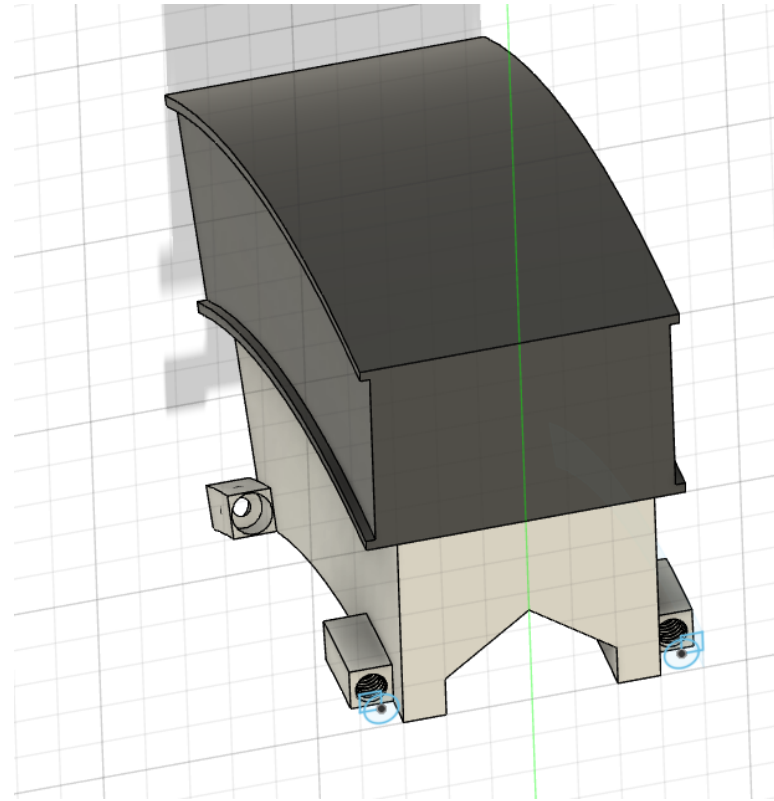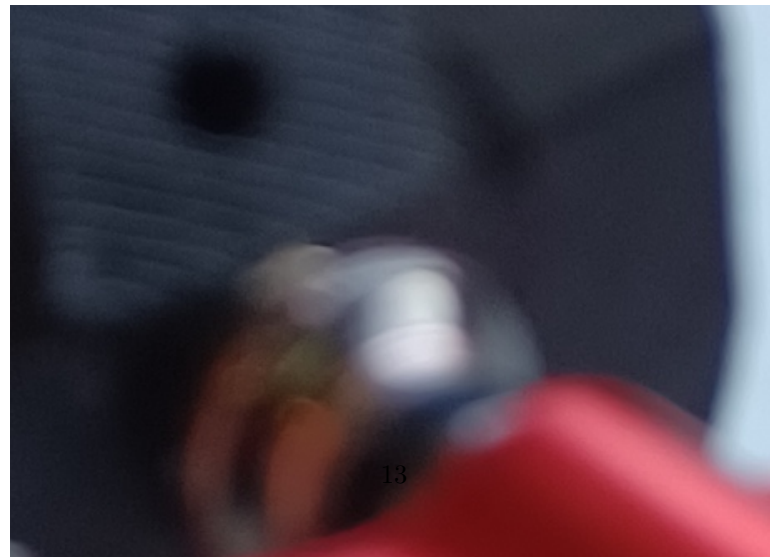| Part name	Material	Print time (min)
Bearing	NylonX	60

Figure 15: Redesigned sectional core of outer wheel, showing where large bearing pieces could go. The tire portion in PEEK material is shown in the upper section.
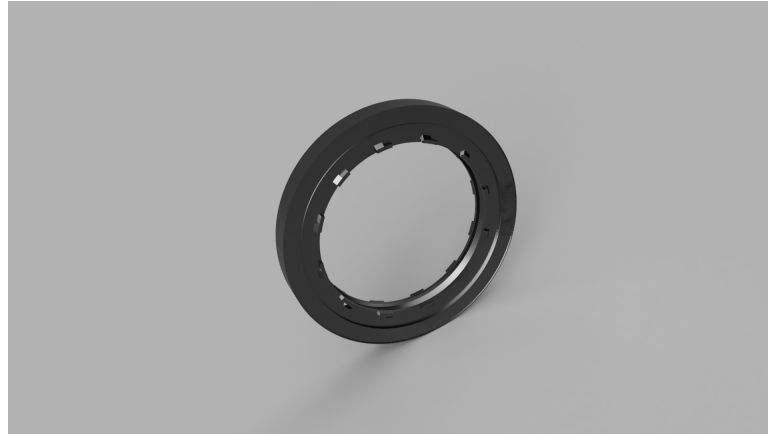
Figure 16: Redesigned outer wheel again, in the shape of a large bearing. M8 bolts fasten the 30 degree sectional pieces together.
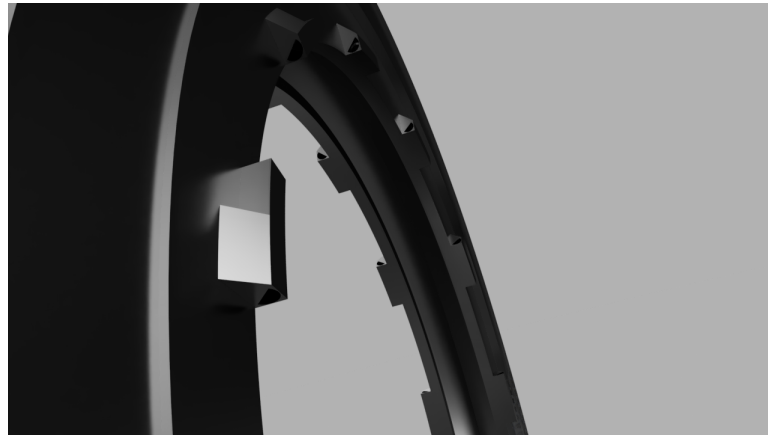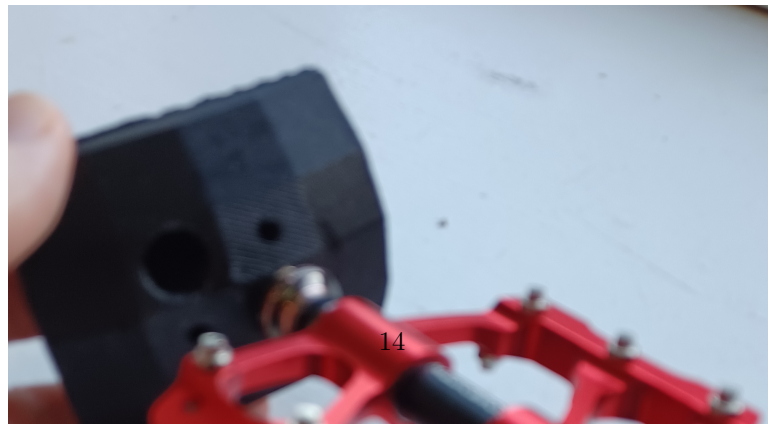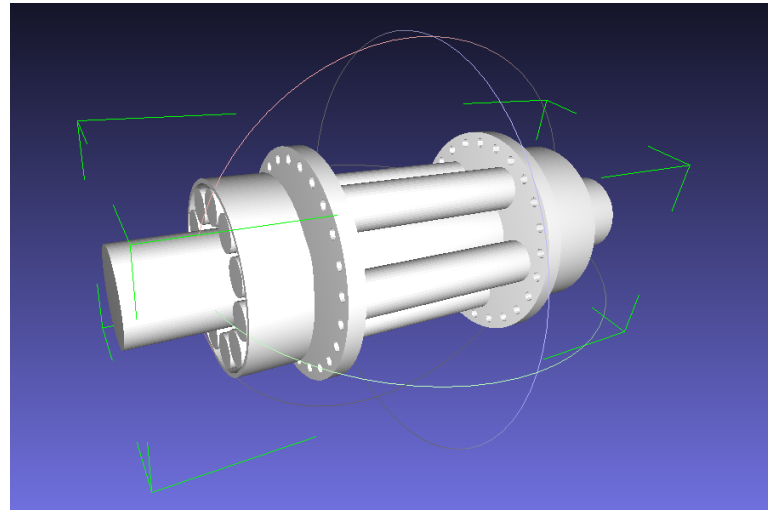

Figure 17: Close up of bolt connection on sectional wheel

Printed with NylonX on the 3d printer, **Biqu BX**

Here is a design using OpenSCAD for a 16mm diameter axle, bearings built on as well as the flanges for the spoke holes. Needs some adjustment and refinement, and a test print with supports (vertical orientation)

7.8   Unicycle Designer

A program unicycle_designer.zip that can read a unicycle.spec file, for generating a set of base .stl files. At first, a modeler will have to be used to go through and add various holes and threads, such as for M8 bolts.

7.8.1   Specifications

An example **unicycle.spec** file

```
wheeldiam=24
seat=0
axle=0
handle=1
wheelbearingv=0.5
pedal=170
```

The idea will be to have a high level main or global area of definitions, and then some sub areas such as seat, and pedal, for further customization. Wheel

diameter is in **inches** however the other units are **millimeter**.

7.8.2   Config settings

Config setting	Type	Description	Default value
wheeldiam	Inches		24.0
seat	Bool		0
handle	Bool		1
axle	Bool	Protruding axle on hub plates	0
wheelbearingv	Percent	Bearing rollers closer to wheel rim, or hub	0.5
pedal	Millimeter		170.0

7.8.3   Templates

For example, to further test this approach a unicycle36.spec could be created with a 36" wheel diameter, seat, etc. For that model the idea would be to see what kind of additional build volumes are available for 3d printing, so as not to split the stl model files excessively.

7.8.4   Other settings

Another setting to consider – is the bearing design on an axle, or around a set of central hub discs / plates?

At first the design will be for a larger set of bearings around a hub disc / plate.

8   Prototype videos

Video 1
Video 2

9   Future

The Lithium Ion cells, a charging circuit, speed sensor, Raspberry Pi board will be designed in and added once the basic unicycle is functional.

9.1   Electric motor

Redesign everything again with a motorized core? Gearbox?

Additional battery packs for higher voltage, motor controller, etc.

9.2   Make it closer to fully 3d printed

(*Optional*) If there is interest, design mountain bike pedals. Consider learning CNC machine for aluminum pedals, or trying a carbon fiber print.

(*Optional*) Design a seat and cut the fabric material, with suitable amount of foam to be assemebled together.

9.3   Other ideas

LED lighting to illuminate the unicycle.

10   Links