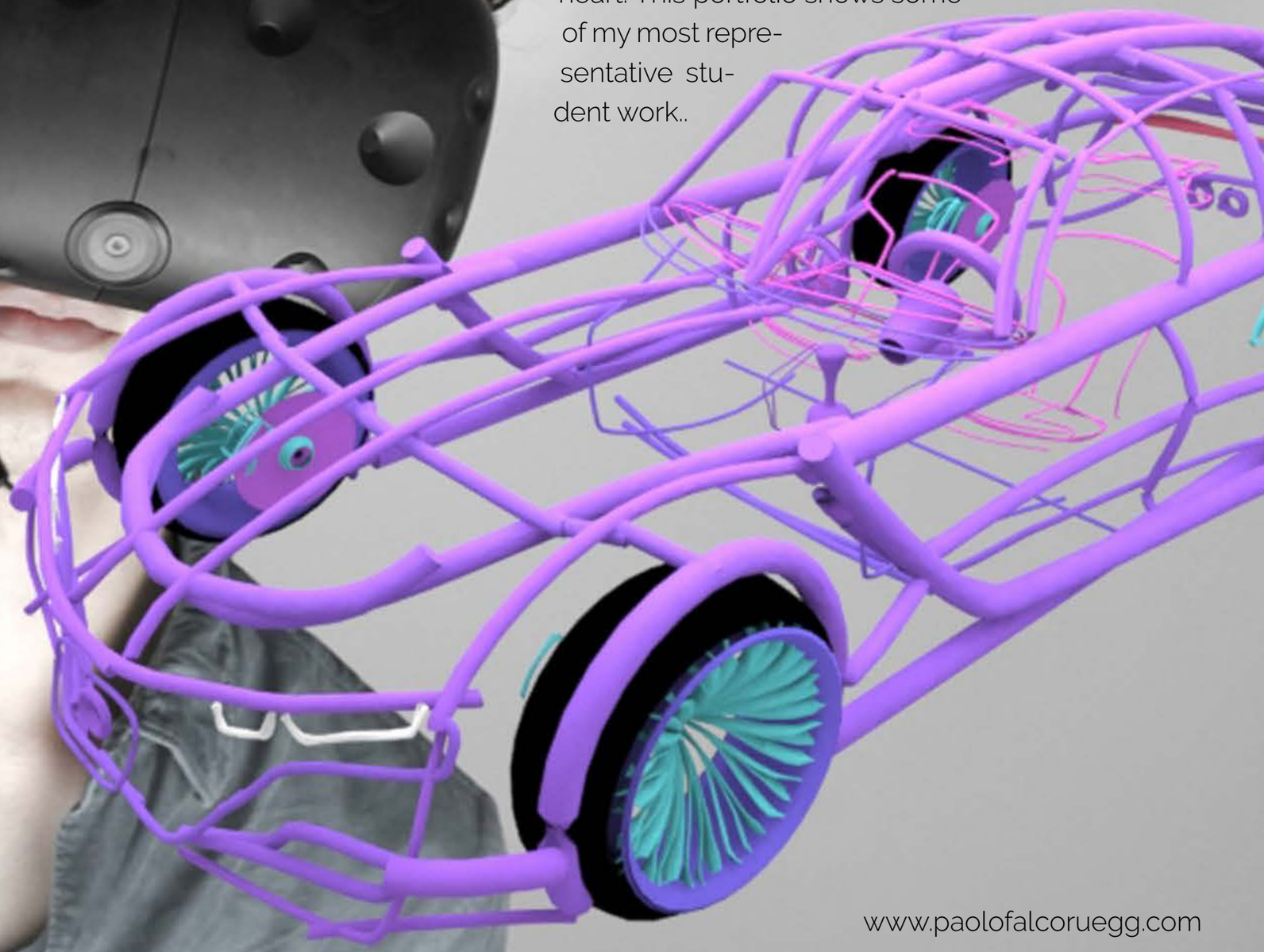
Paolo Falco Rüegg

Design Engineer

Hello! I design products that work on the inside and that work for you. By fusing design thinking with engineering practise I aim to achieve a satisfying and functional product. My day consists of sketching, calculations, CAD, FEA, programming and wiring microcontrollers up. And a lot of time in the workshop, as I am a maker at heart. This portfolio shows some of my most representative student work..



www.paolofalcoruegg.com

1 MINIWHEG

ROBOTICS | SOLIDWORKS | MECH. ENGINEEERING

> *A small and mobile robot featuring whegs, a combination of a wheel and a leg, as well as a grab and drag mechanism.*

The aim of this assignment was to present a fully engineered design and CAD for an improved MiniWheg. These robots can climb obstacles larger than their wheel radius and are less than 20 cm in length.

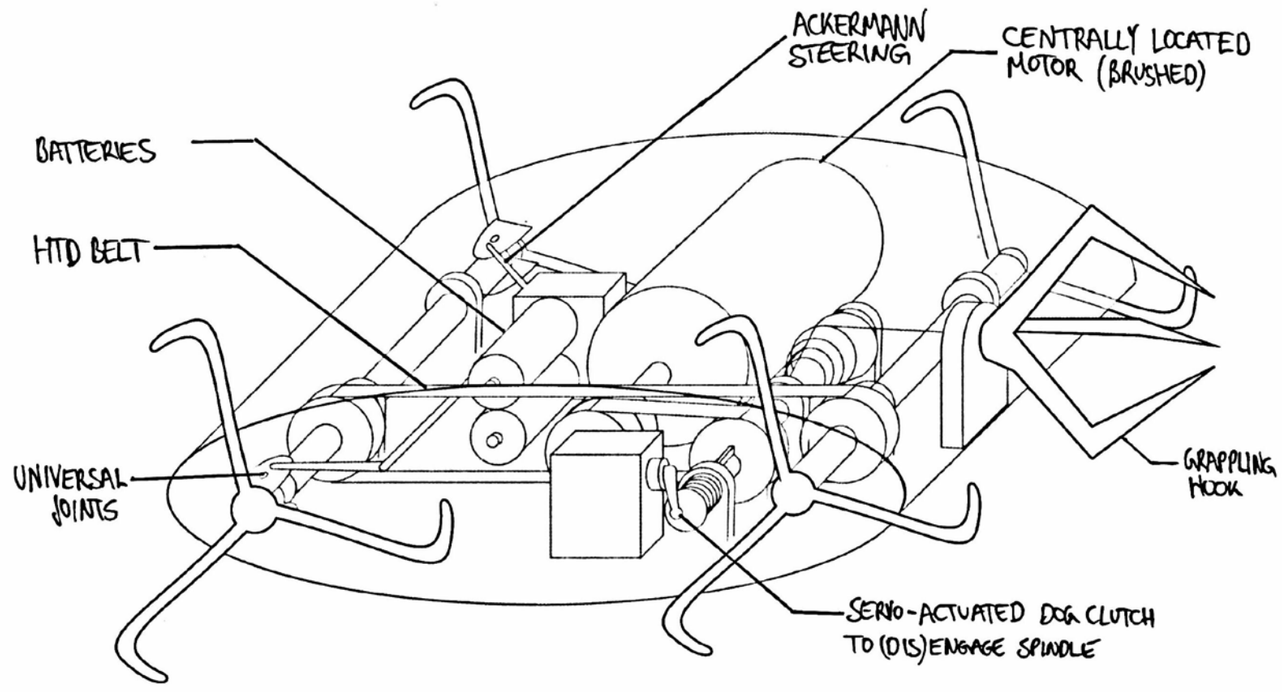
101 Research & Inspiration

The ideation phase was at the time of a set of earthquakes in Italy. This served as inspiration to come up with a design that could help removing debris after natural catastrophes. Having researched into animal locomotion, inspiration was taken from the worker ant.

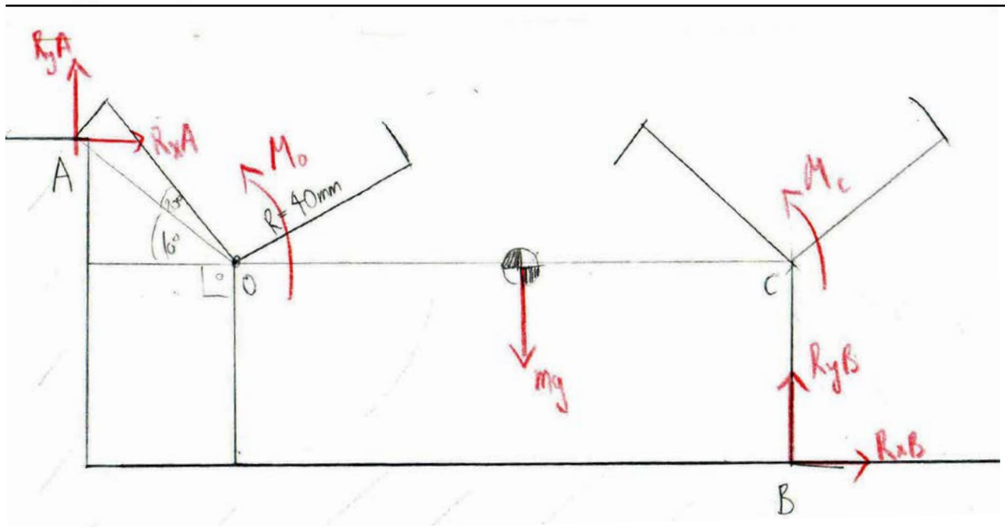
DRIVE	FOUR WHEEL	FRONT	REAR	SIDE	DIFFERENTIAL FOUR WHEEL
STEERING	RACK & PINION	SLIDING	STEPPER W/ BELT	STEPPER W/ CHAIN	SERVO
SPECIAL FEATURE	DIGGING	GLIDING	GRAB & DRAG	ROBUSTNESS (TANK)	AMPHIBIAN

102 Concept

The robot features a grab and drag mechanism, meaning the object is dragged along behind the robot. In this way, the robot does not have to carry the weight of the object, but only overcome the frictional force required to drag it.



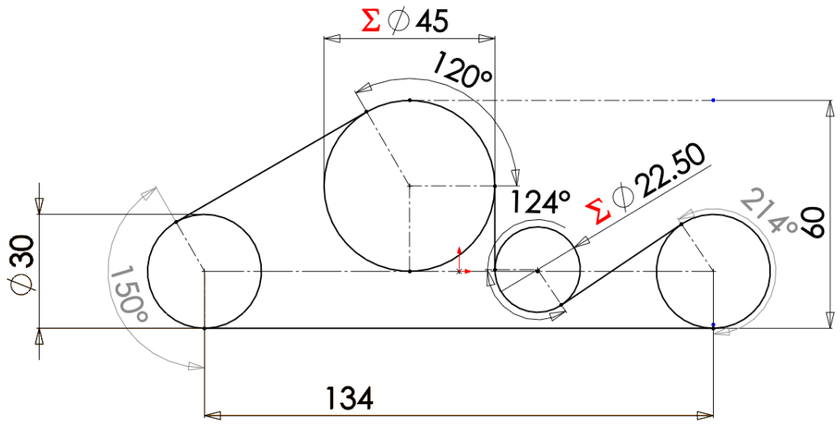
103 Engineering Analysis

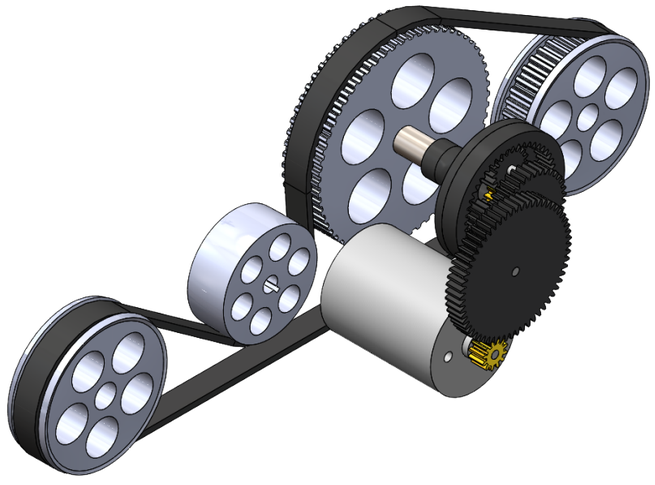


A Free Body Diagram gave a rough estimate of the torque required to overcome obstacles and drag objects along. A dynamic Excel sheet was then created to calculate the torque and RPM required for different robot / wheel dimensions.

104 Transmission

The first stage was a HTD belt system consisting of pulleys available off-the-shelf. A planetary gearbox with added compound spur gears ensured the correct RPM reduction was achieved.

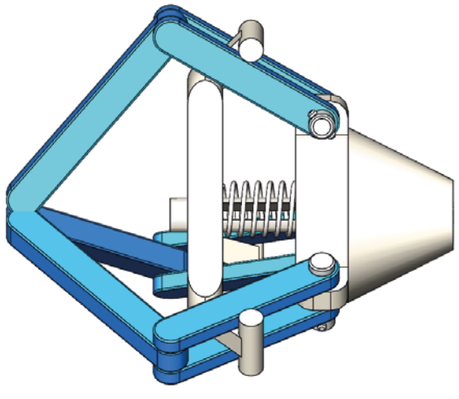




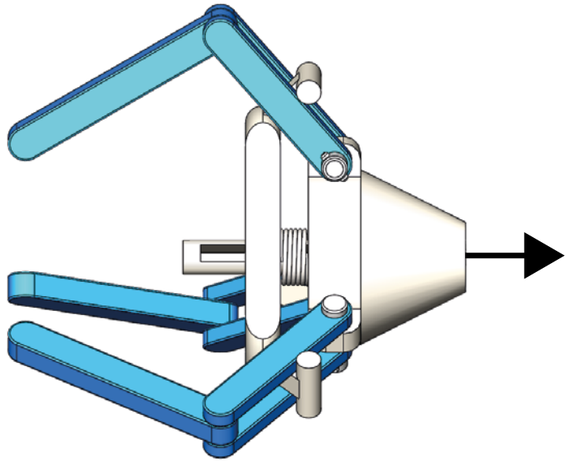
106 Gripper

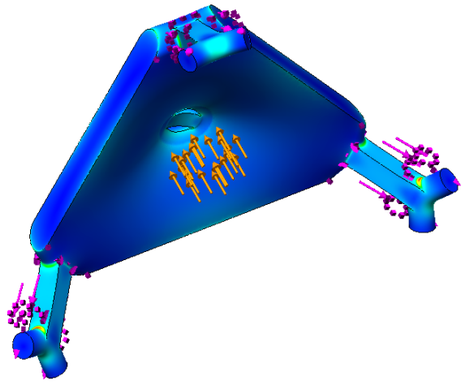
A spring-loaded system was designed to grab objects. The configuration of the gripper is dependent on the cable tension, which in turn was controlled by the motor. A servo-actuated dog clutch linked the gripper to the motor. FEA was run on several components it to ensure they would withstand the loads.

CLOSED



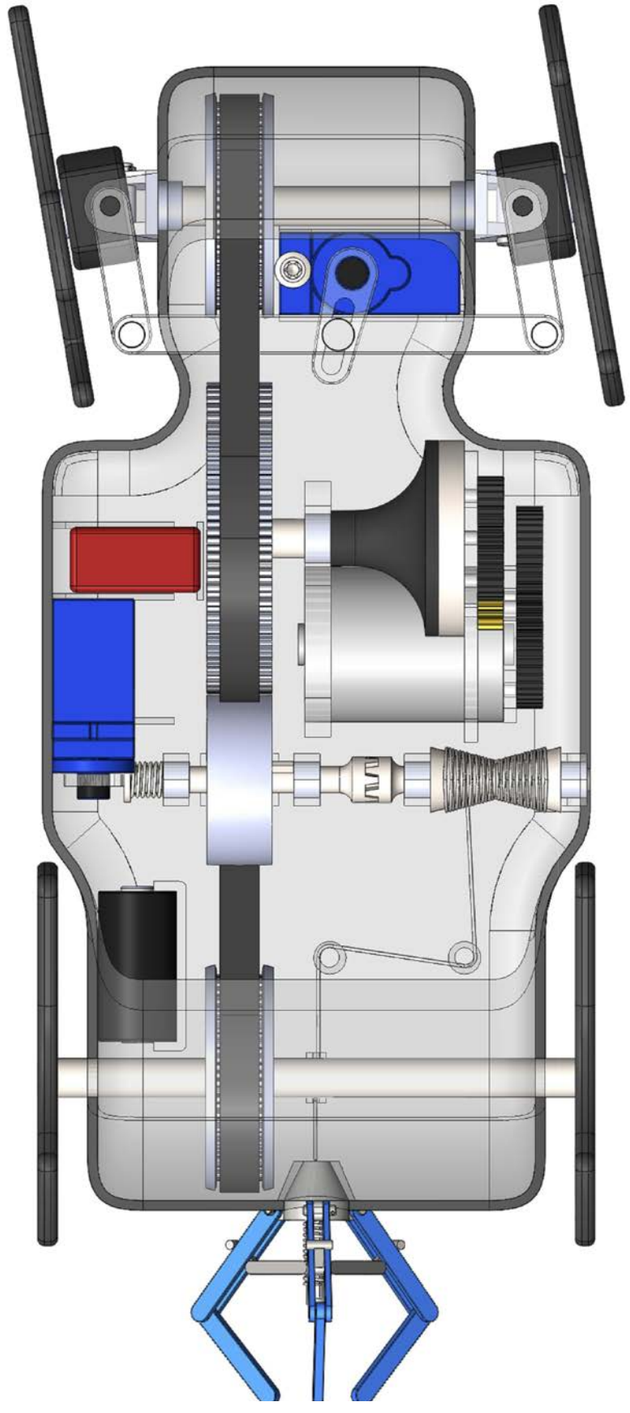
OPEN (CABLE TENSION APPLIED)



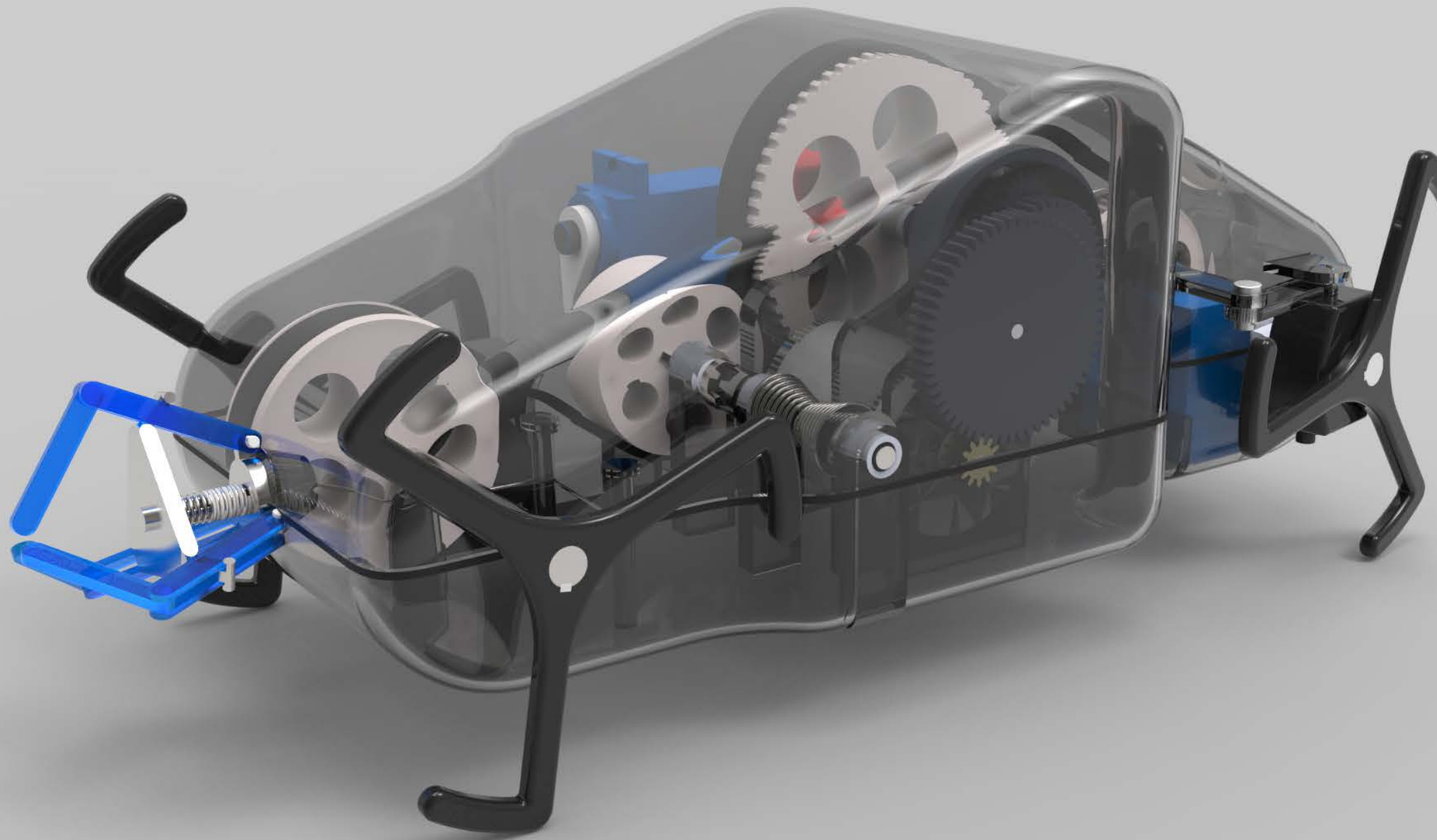


105 Steering

A servo-actuated Ackermann steering was designed to achieve the required turning circle.



107 Final Model

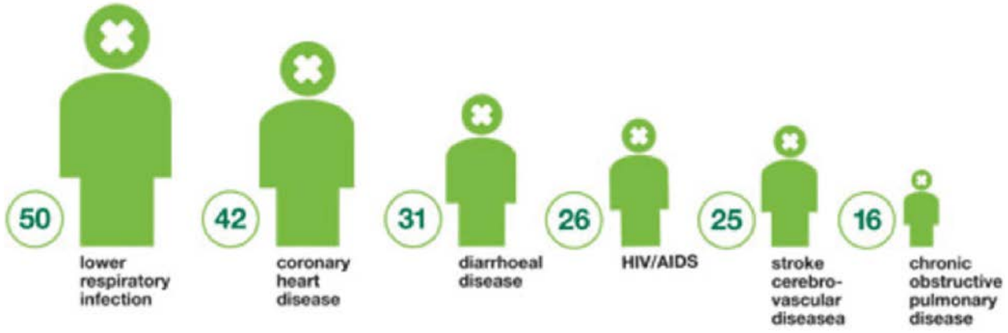


2 BREEZE

MEDTECH | LUNG FUNCTION | PRODUCT DESIGN

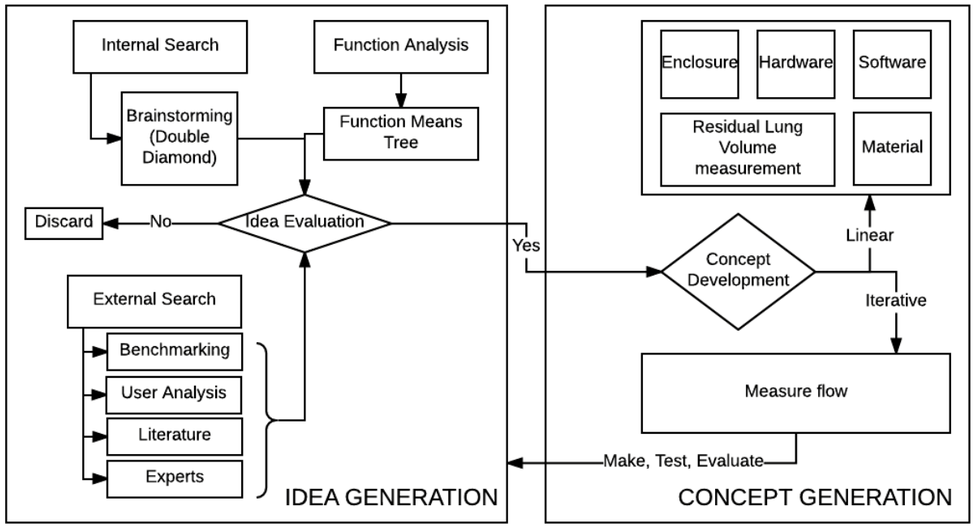
> *A low-cost spirometer to combat respiratory diseases in developing nations. The product is wireless, battery-powered and sends its results to any smart device.*

The brief for this project was to design a non-invasive and low-cost device for measuring tidal lung volumes. A spirometer measures the breath and indicates if the lungs are obstructed, a major cause of death in low-income countries.



201 User Research

We decomposed the design problem and analysed the user base. Research at the Royal Brompton hospital was undertaken to identify current solutions and ergonomic requirements.

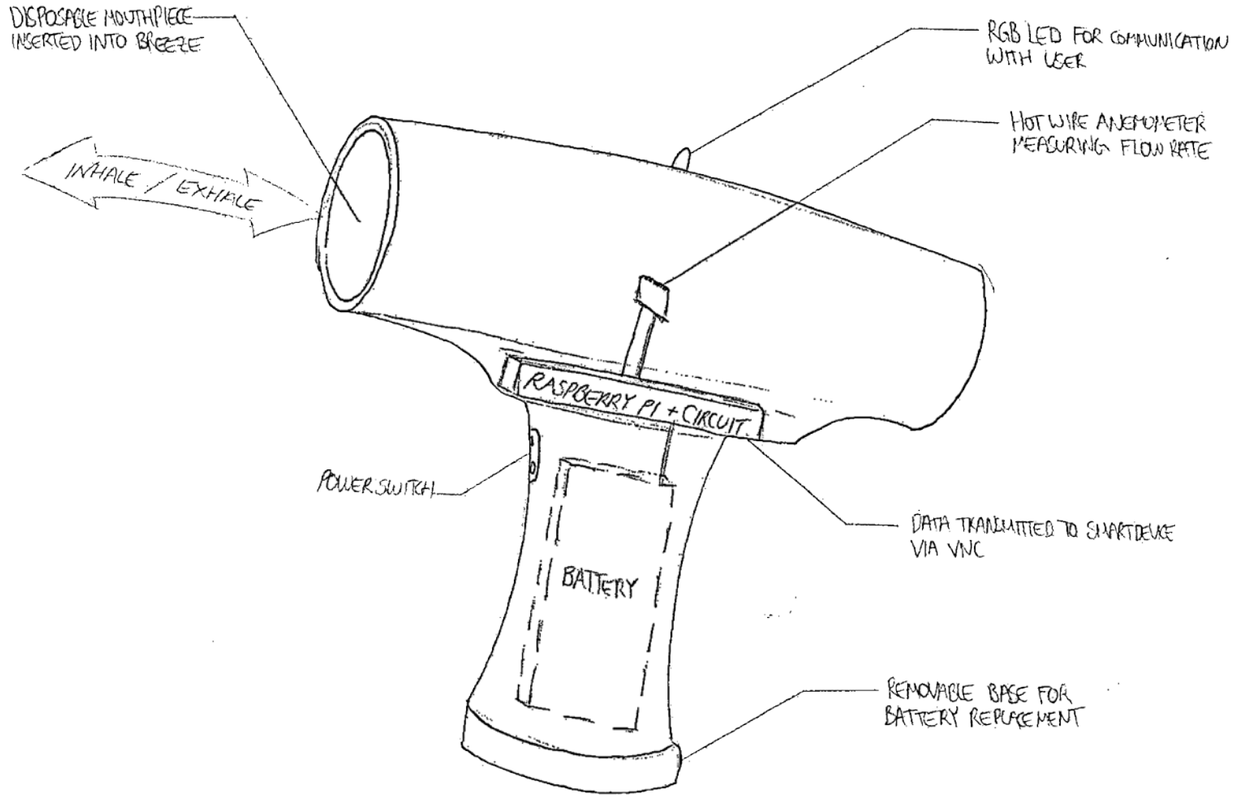


202 Design Process

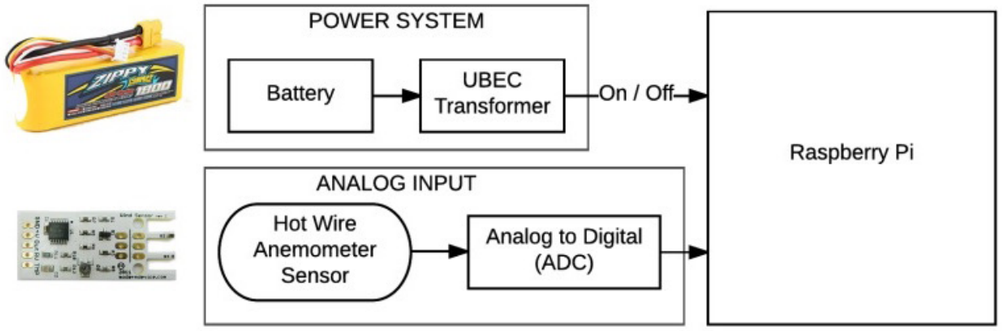
An initial product specification was constructed, covering all the user needs identified. The flowchart on the left was used to subsequently generate concepts. A particular emphasis was set on how to measure flow, where Arduino prototypes were quickly made, tested and evaluated.

203 Concept

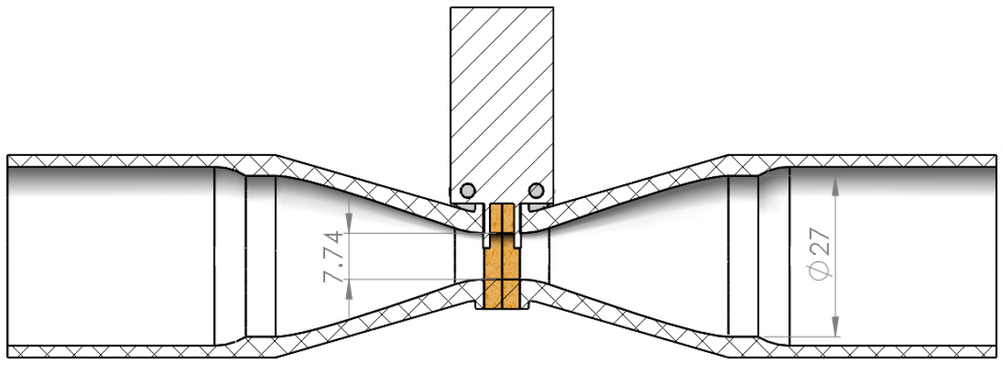
The spirometer has a modular approach, with a main device and an add-on for extended measurements. On either side of the air channel, disposable mouthpieces can be inserted to breath into the device.



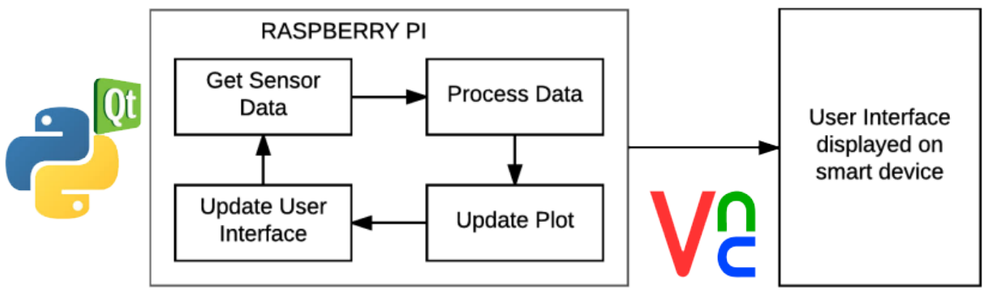
202 Hardware Design & Signal Processing



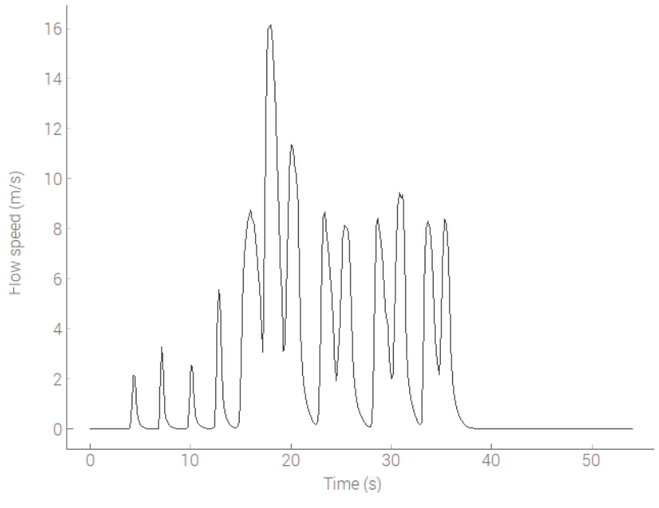
The equations needed to calculate the metrics of interest (breath speed, flow rate, and volume) were derived from fluid dynamics, and relate to the cross-section of the air channel.

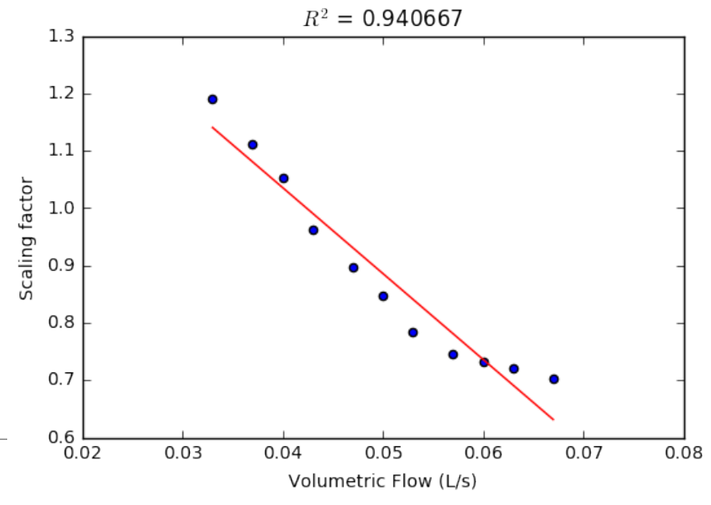


205 Software & Calibration



The graphs on the right was plotted using PyQtGraph. This library fitted in seamlessly with Qt, the framework used for the digital user interface. A regression model was created to calibrate the device.





206 Working Prototype

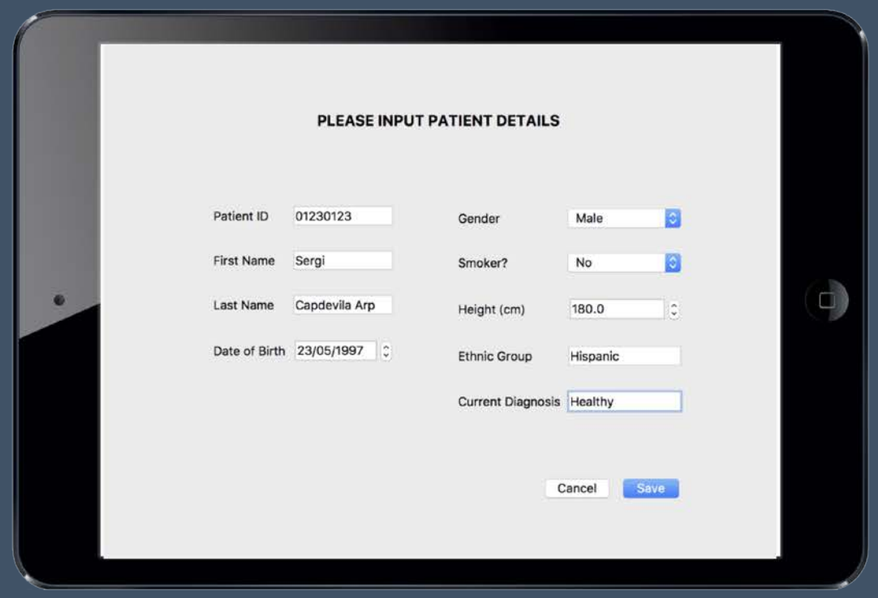
All the components including the power system were integrated into a 3D-printed enclosure. The device was therefore fully wireless.

207 Final Prototypes

User testing revealed that the original design could create strain on the wrist when helf for a prolonged time. An updated ‚lookalike‘ model was created and printed. The working prototype is shown on the far right, fully assembled and functional.

208 User Interface

The UI displays real-time graphs of the user‘s breath. It is able to calculate the volume of each breath, as well as the flow rate and the breath speed. As previously mentioned, this UI works on any smart device, and is sent wirelessly by the Raspberry Pi. It was programmed fully in Python.



3 AIR

FMCGs | MINIMALISM | SUSTAINABLE DESIGN

> ***A minimal razor that uses the least material possible. When the two sides are pressed together, the hinge separates and the cartridge can be replaced.***

This award winning razor is an answer to the short-lived products available on the current market. The brief was to analyse and redesign an existing razor for sustaiability.

DESIRE award winner for ‚The Best Razor Design'. Awarded by the Dyson School of Design Engineering

301 User Research

Q. *‚What makes a user hold on to a razor?'*

A. *Interviews / Questionnaires*

Premium feel through aesthetics and material choice

Product creates emotional attachment through effective marketing

Razor is used in a novel, unconventional way

302 Benchmarking

An existing product was torn down and a Life Cycle Assessment was created. Most of the energy and CO_2 footprint lied in the material domain. The design goals were set out as:

No. of parts ↘ Mass ↘

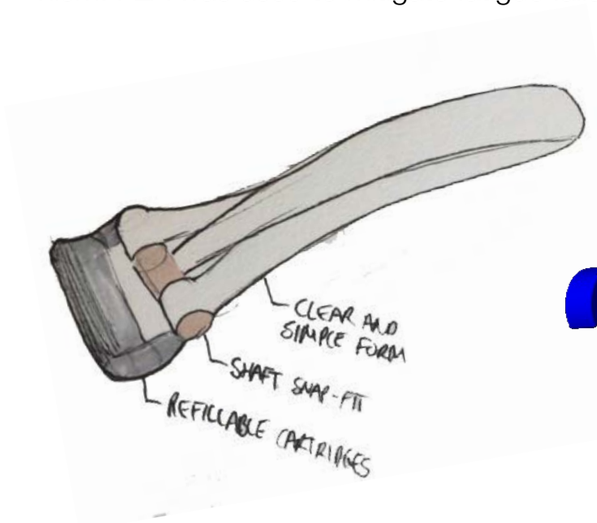
303 Redesigning for sustainability

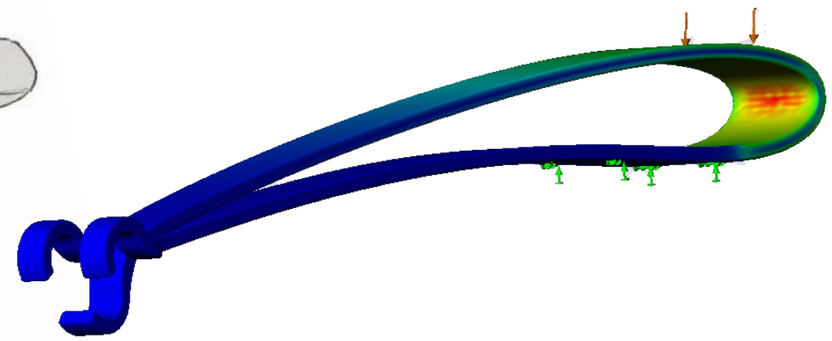
I wanted to design a product for a user segment looking for interesting aesthetics within a sustainable service system. As a designer, the most viable way of achieving this target was to dematerialise as much as possible.

> ***‚Air is a minimal razor that uses the least amount of material possible'***

304 Concept Development

To minimise manufacturing and recycling efforts, the handle was ideated as a single part. Using sheet metal enabled the design to be flexible, which would be of particular importance to the cartridge change mechanism. FEA was used to mitigate fatigue failure.





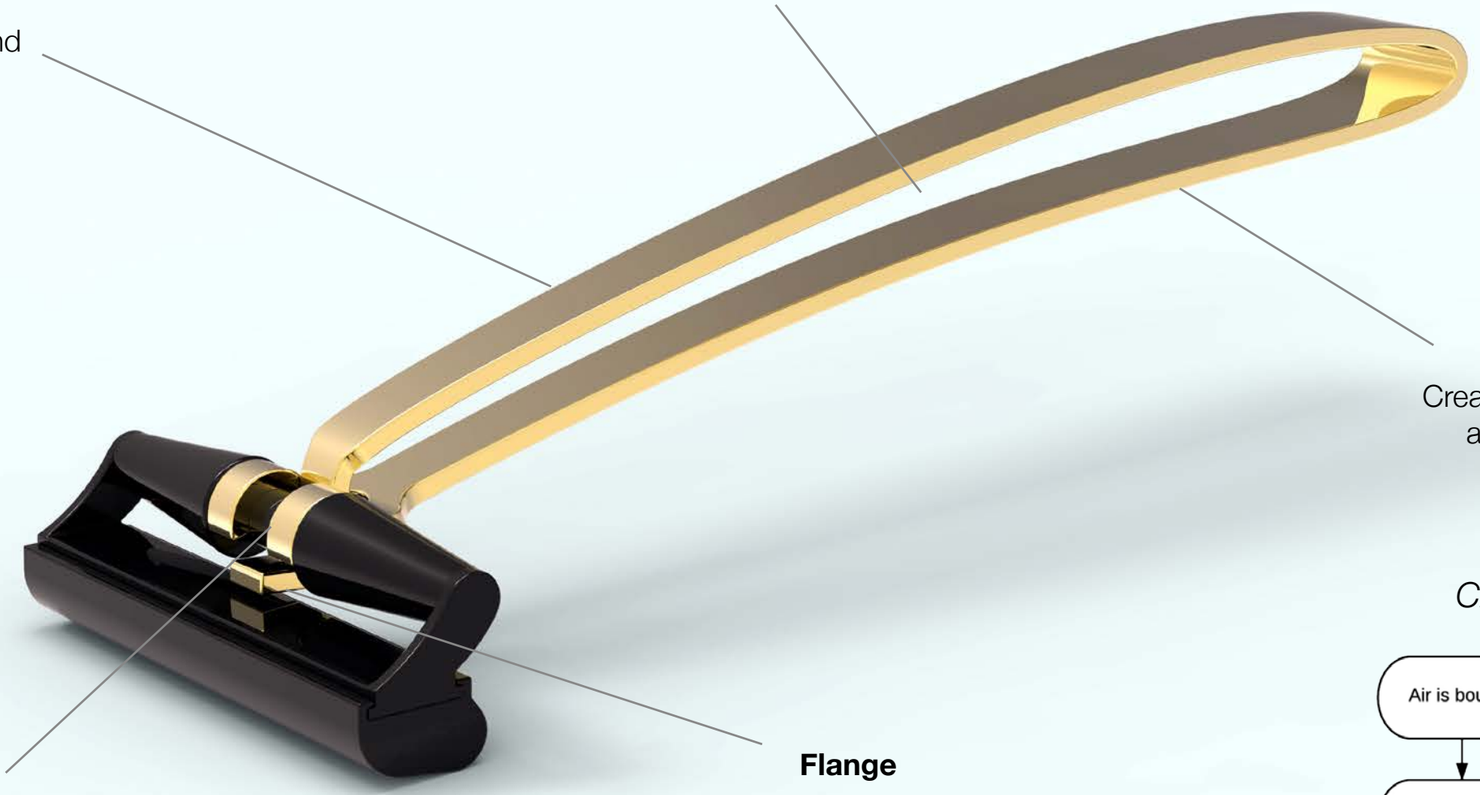
305 Concept

Dematerialisation

The minimalist form is defined despite low volume and mass

Brass

An elegant, sustainable and easily recyclable metal



Streamlining

Creates a nice aesthetic and is ergonomic

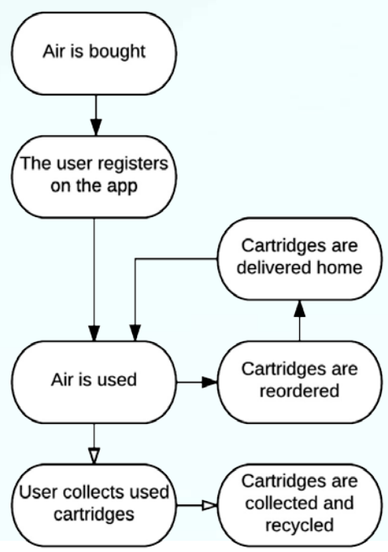
Cartridge change

When the two sides are pressed together, the hinges separate and a new cartridge can be inserted

Flange

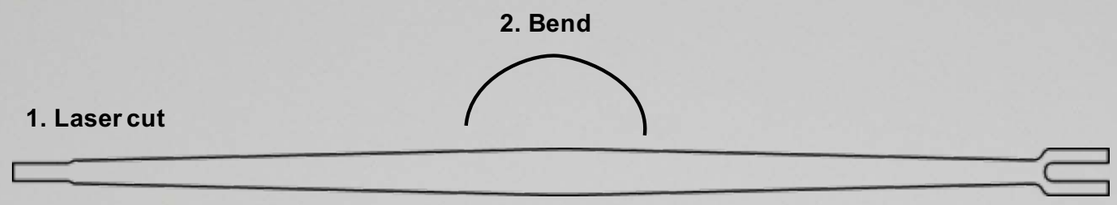
The flange limits the rotation of the head

Circular Product Service System



306 Prototyping

Air is very easy to manufacture. For mass production, the blank is stamped out and subsequently bent. These processes are cheap and low in energy usage.

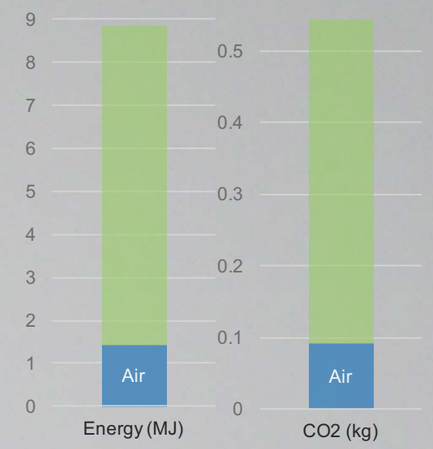


307 Benefits of Air

80% Reduction in energy and CO_2 footprint

46% Reduction in mass

...compared to the benchmarked product, shown in green.



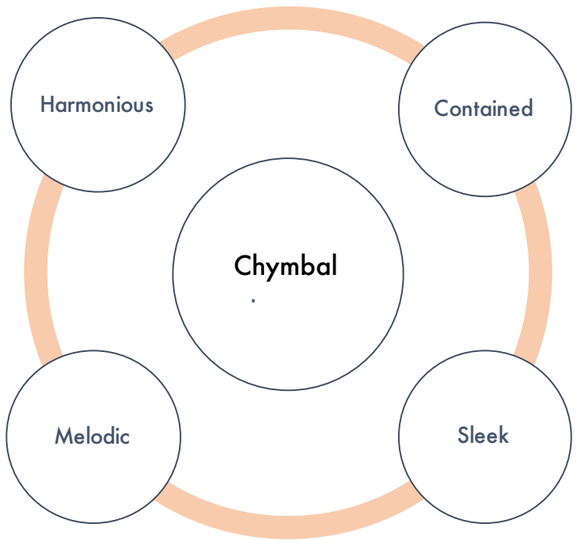
4 CHYMBAL

MECHATRONICS | CNC ROBOT | MUSIC

> *An electromechanical machine that generates sound by integrating machine elements, electronic control systems and sound design*

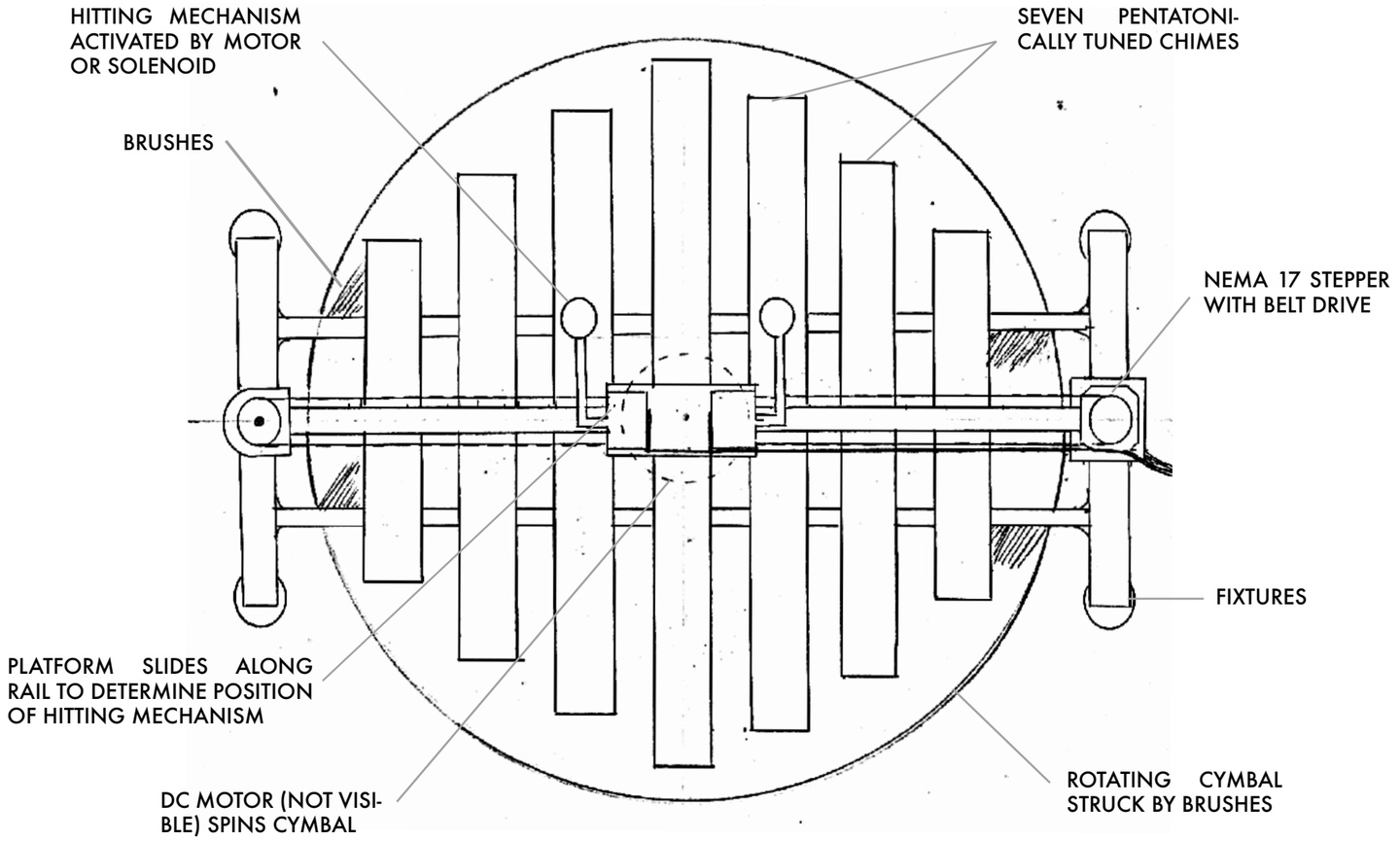
This assignment was about building a mechatronic device that makes music. The aim of *Chymbal* was to become acquainted with complex electromechanical systems.

401 Core Requirements



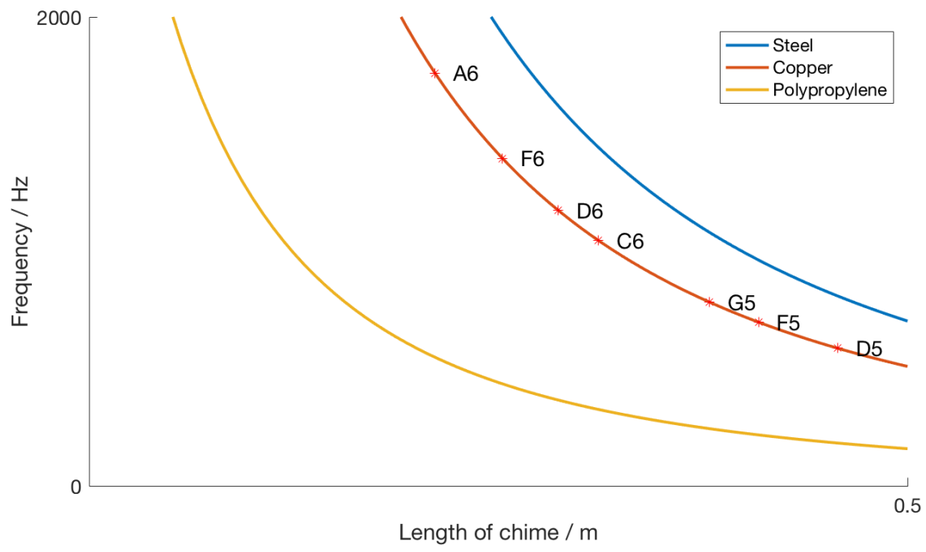
402 Concept

A platform moves above an array of chimes and changes position through a belt drive. Two hitting mechanisms are mounted on the platform, striking the chimes and creating harmonies. A cymbal rotates underneath the chimes, where stationary brushes create a background sound.



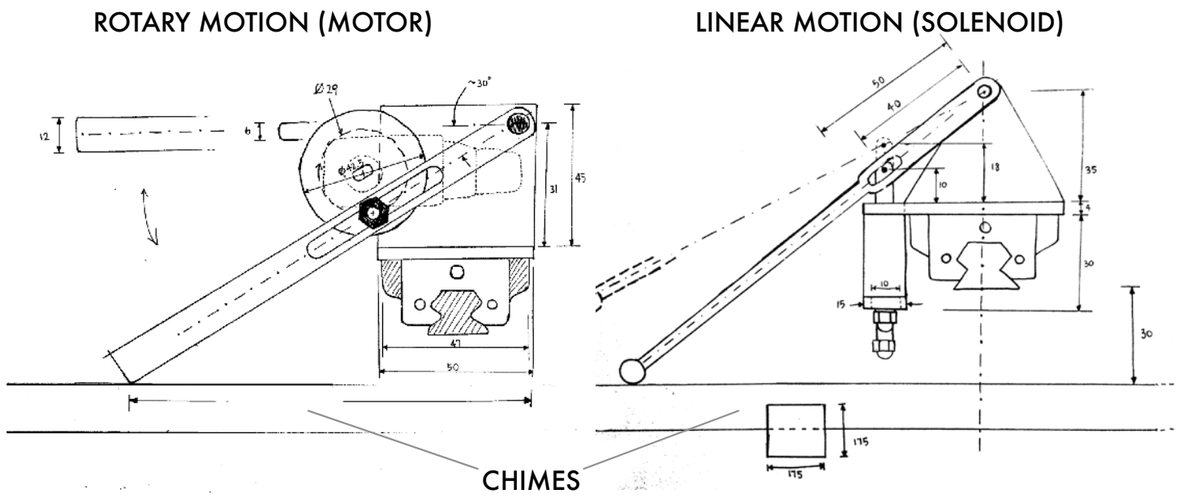
403 Sound Design

A Matlab study was used to predict the dominant frequency for chimes of different lengths. A pentatonic scale was selected to avoid dissonant chords. Copper was chosen due to its optimal resonant properties.



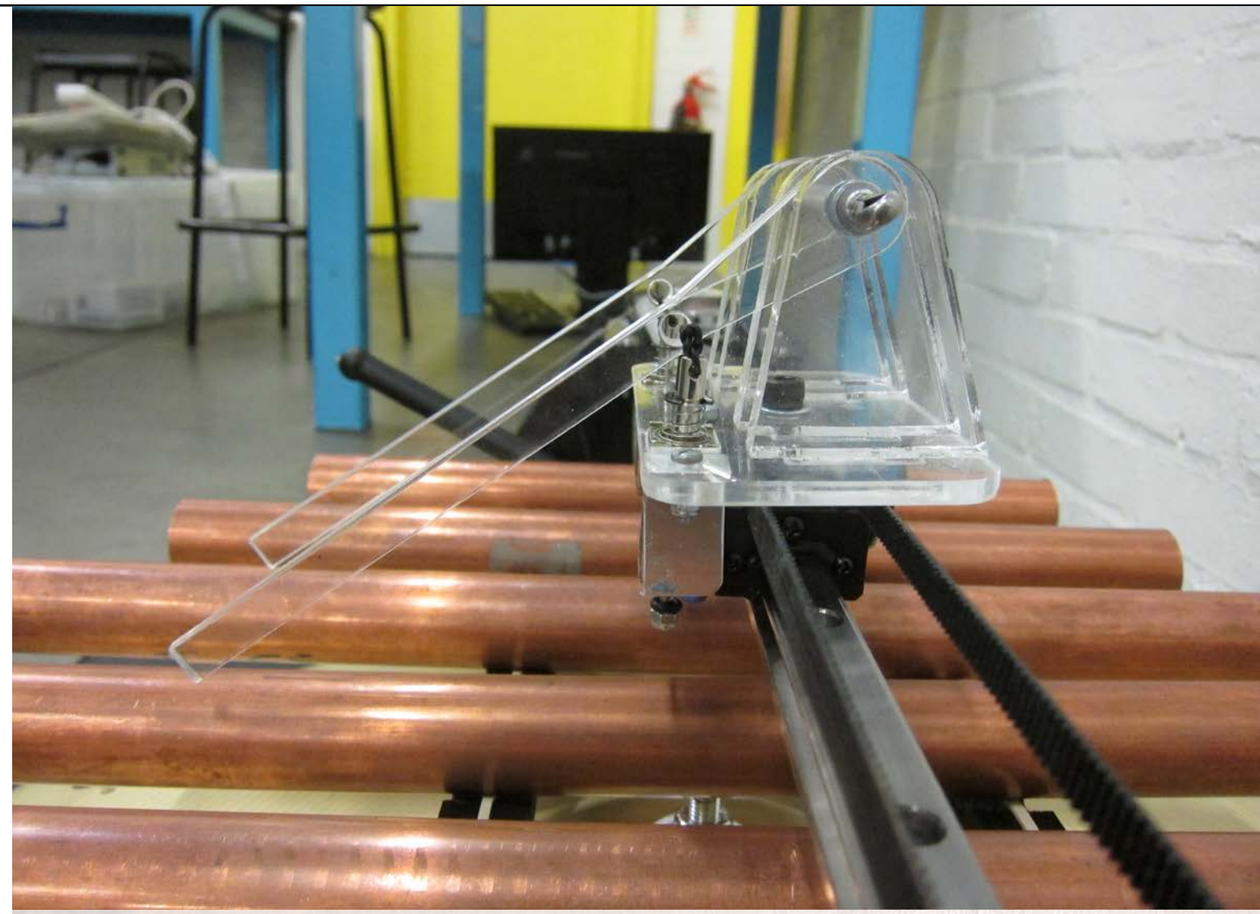
404 Mechanical Design

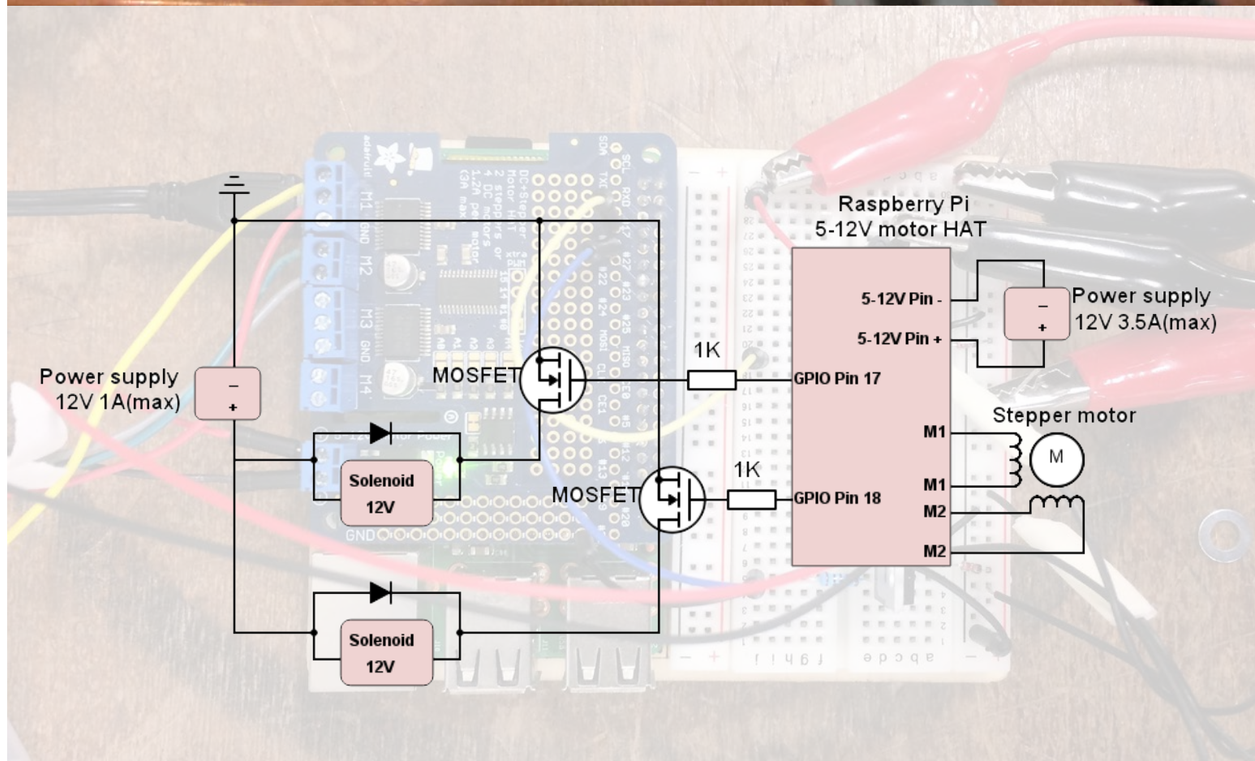
Several concepts were generated for striking the chimes, two of which are shown below. Developing the solenoid mechanism was the way forward, as it was a reliable actuator and prevented problems with positional drift over time.



The belt drive was adapted from off-the-shelf parts, held in place by a 3D-printed frame.

Control was achieved through a Raspberry Pi. A Qt-based user interface allowed the user to interact with Chymbal. The different notes and rhythms could be selected, which the device then played.





405 Final Build

The UI to control the machine is shown on the bottom right. Clicking the chimes would queue the notes and rhymthms. Chymbal would then play the user's composition.