Design Portfolio

Agoston Walter

April 27, 2020

Measurect

November 2019 – April 2020

University Final Project for Biomedical Engineering – Group Project

Descriptive Paragraph:

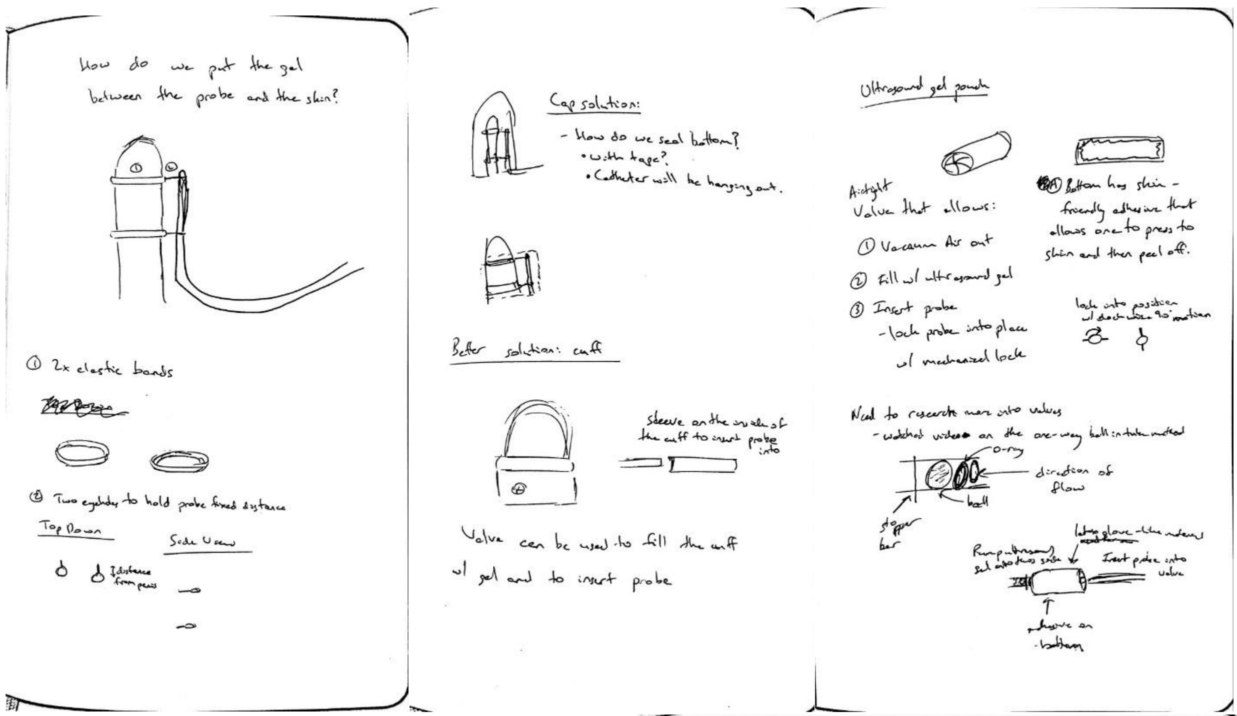
Male spinal cord injury (SCI) patients have erectile dysfunction due to their sustained injuries, which worsens their quality of life. Current therapies such as Viagra do not solve the problem of erectile dysfunction in male SCI patients, spurring researchers at Duke and across the United States to look for other cures. A major setback for the researchers is that there is no universally accepted device to measure the stiffness of a penis during erection, the erection metric that is critical to successful coitus. Dr. Casey Steadman, a researcher at Duke, reached out to my Biomedical engineering design group with this design problem: to create a device that can accurately measure the stiffness of the penis over a period of two hours. With this device, Dr. Steadman can run her study on new therapies for the male SCI patients and have a robust, accurate tool to gauge the effectiveness of her treatments. There currently exists a variety of methods to measure erectile function, but all of them have significant issues such as a lack of evidence linking the data the sensor is measuring to penile stiffness, or interference with the actual erection. Our group performed extensive background research into this design problem, and we found that using ultrasound to measure the stiffness of the tissue is the optimal solution. The professor for the design class, Dr. Mark Palmeri, specializes in ultrasound and lent us an ultrasound probe which we were adapting to use for the project, which is what the first two pages of sketches is referencing. Due to the coronavirus epidemic in the United States, classes at Duke University were cancelled two weeks ago, and we were unable to proceed with the project as planned. Due to the situation, our group can no longer design a solution around the physical ultrasound probe, so we pivoted to designing our ideal device, including the ultrasound probe in our design. We plan on simulating our designed probes with simulation software to verify that they would work, and deliver our designs along with instructions in a report to our client, Dr. Steadman, so that they may create a physical version of the device once the epidemic has ceased. All the sketches below are mine. On this project, my teammates worked on the software and hardware side, while I chose to design the physical product. No user testing was performed, we did not have clearance to test our device on patients.

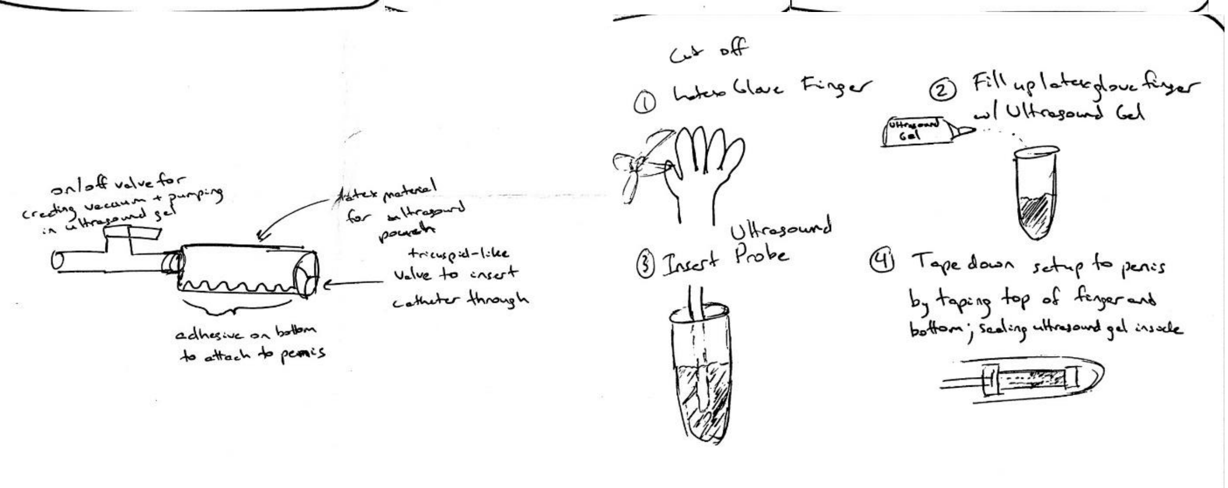
Level of the project: Fourth year (7^{th} and 8^{th} semester)

Name of the supervisors of the project: Dr. Mark Palmeri and Dr. Casey Steadman

Sketches

Designs around the original ultrasound probe (catheter form factor)



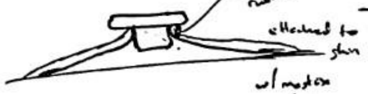


Device Skin Coupling Designs and Testing Results

Concepts

Failure modes

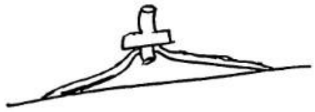
Self sealing Silicone Valve



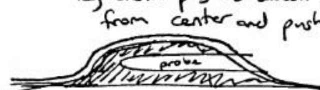
~~Failure modes~~ - needle ~~touches~~ punctures the skin

no way to get air out in this case

IV valve

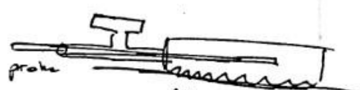


Tegaderm



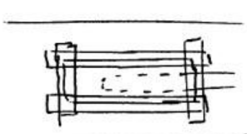
- Incorrect pushing out of air
- Tegaderm does not stay attached to skin for >2 hrs
- Tegaderm leaks U/S gel

Custom U/S Gel Pouch



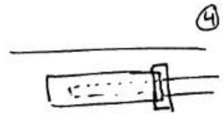
- Valve leaks when probe inserted through it
- mastix spirit gum doesn't hold down latex to skin well

Single walled latex secured to skin w/ mastix



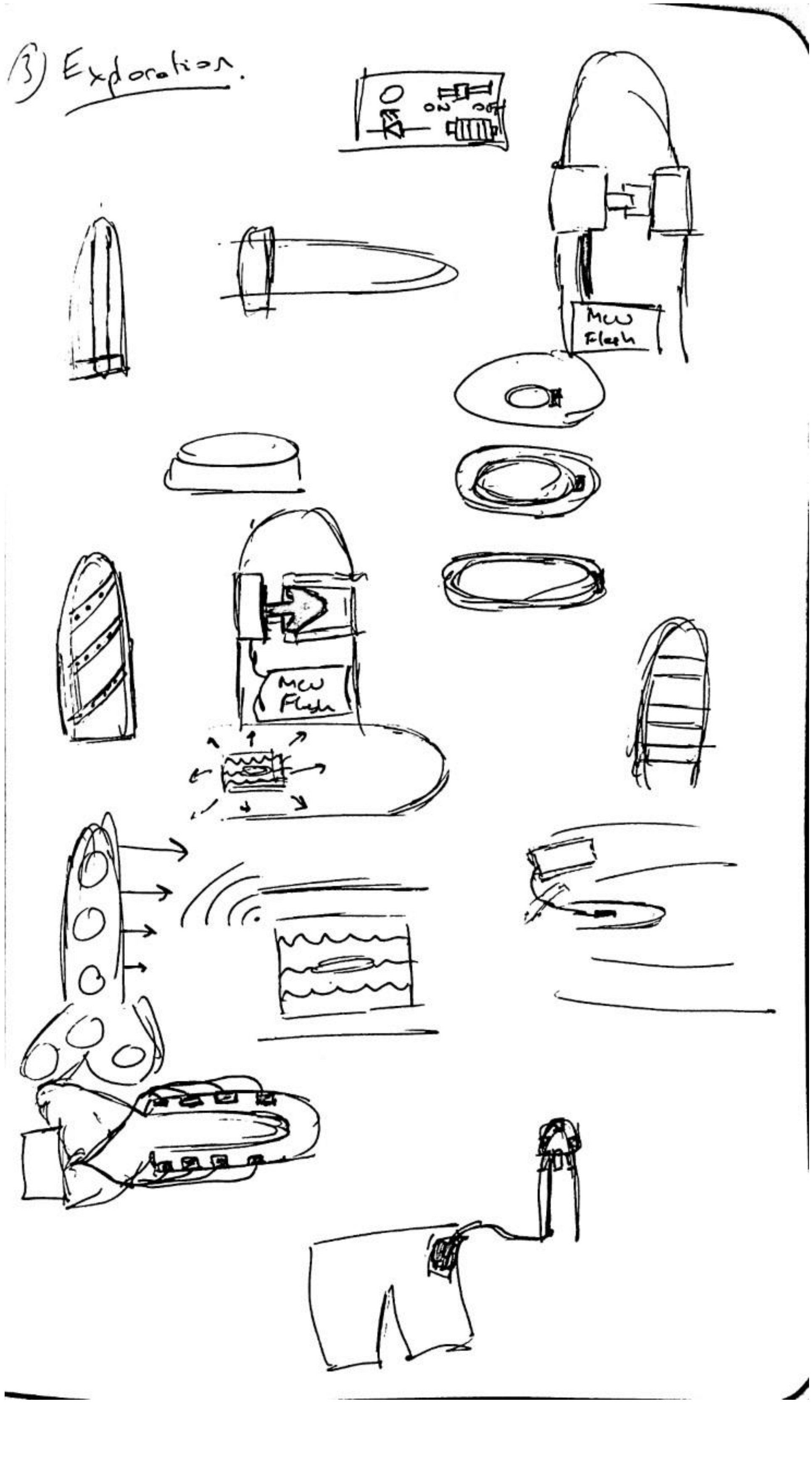
- Same Problem as one side w/ tape
- Mastix spirit gum should solve this problem (replace tape)

double walled latex secured to skin using ~~a~~ either only one side, all four sides, or superglued shut

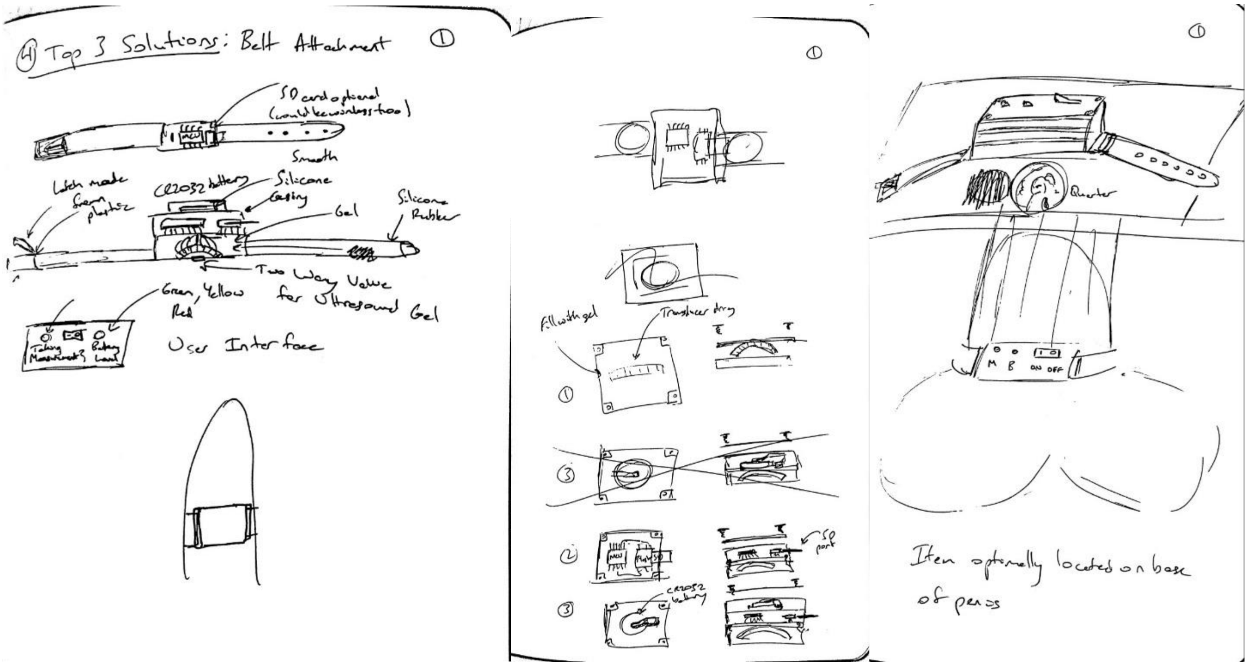


- tape doesn't hold due to ultrasound leaking out (w/ four sides it works better)
- superglue solution worked well under testing

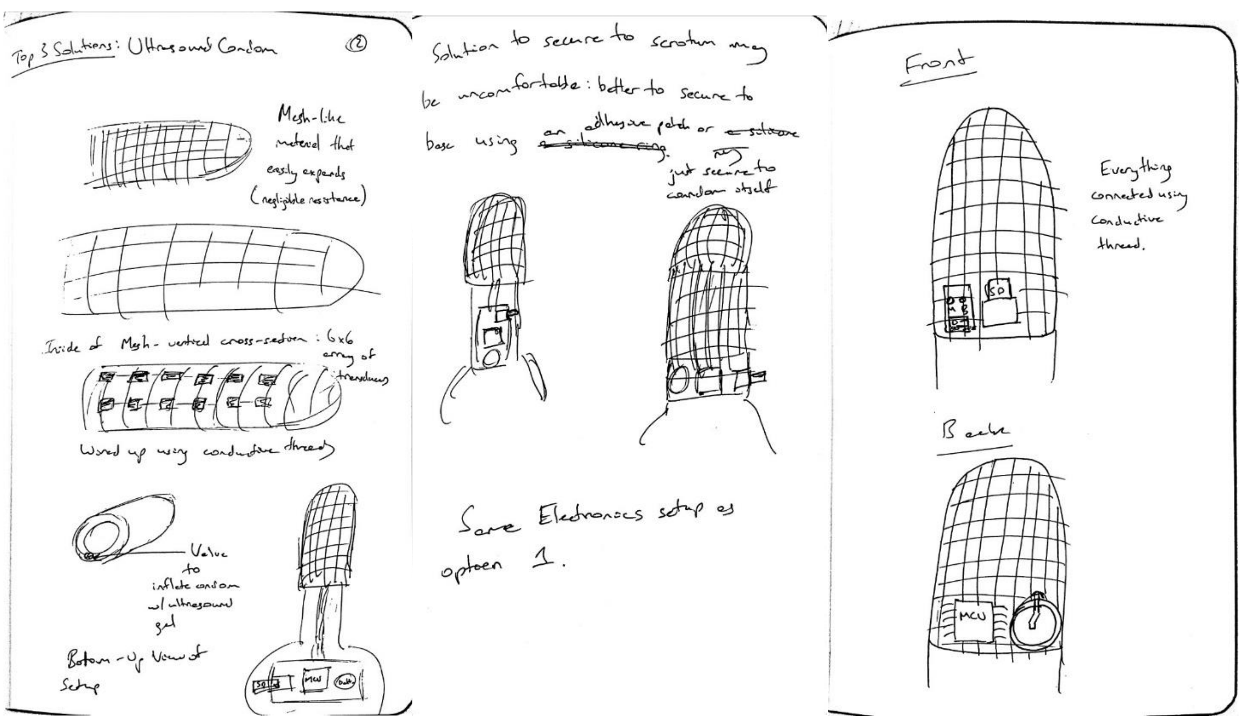
Pivot: No ultrasound probe catheter form factor constraint; free thinking



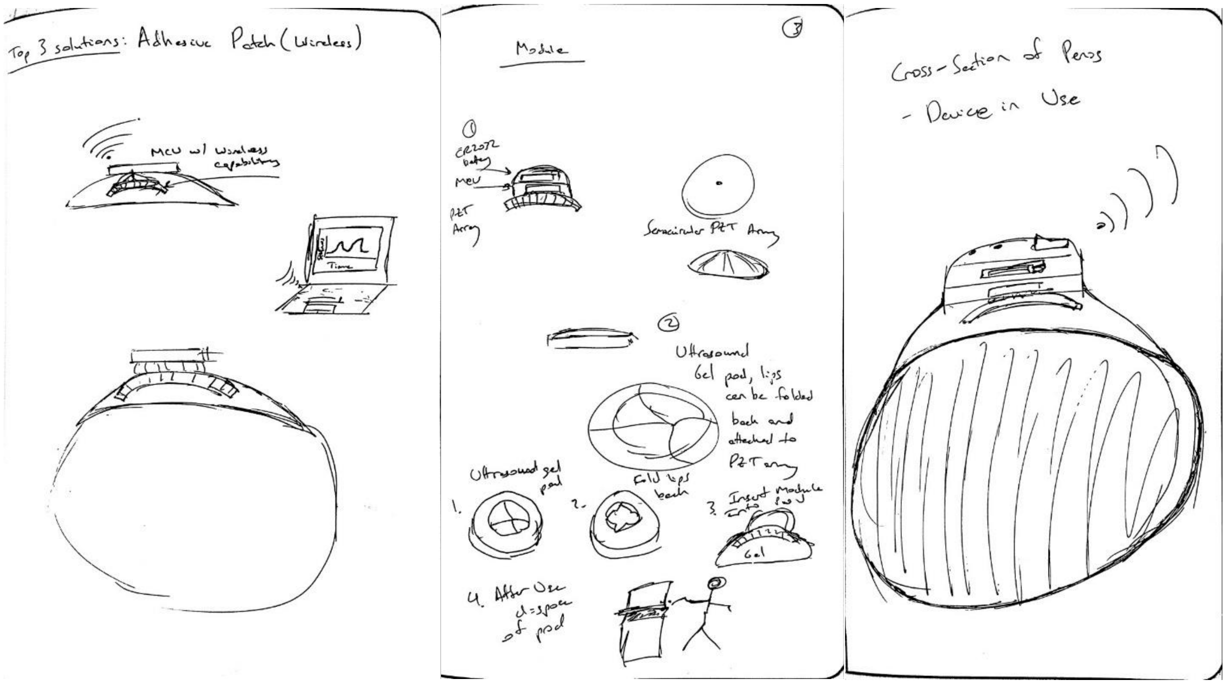
Belt Design Sketch and Investigation:



Ultrasound Condom Design Sketch and Investigation:

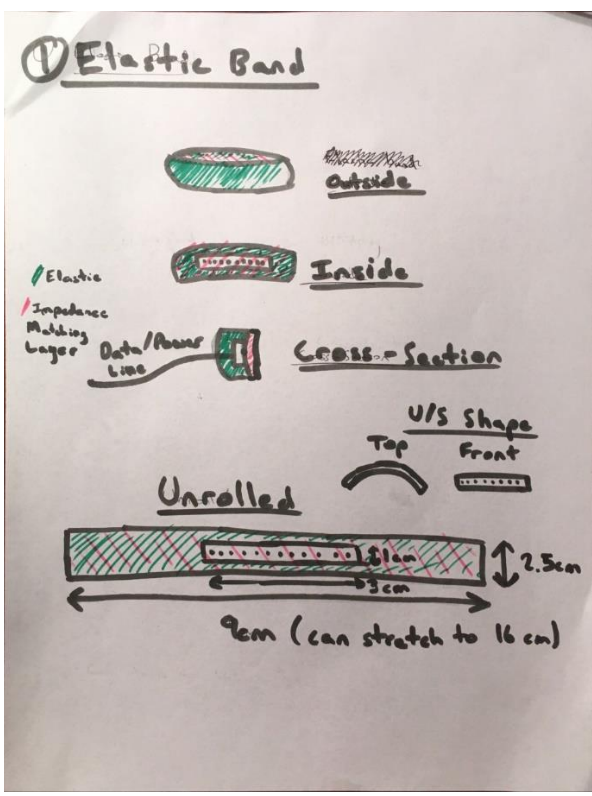


Adhesive Patch Design Sketch and Investigation:

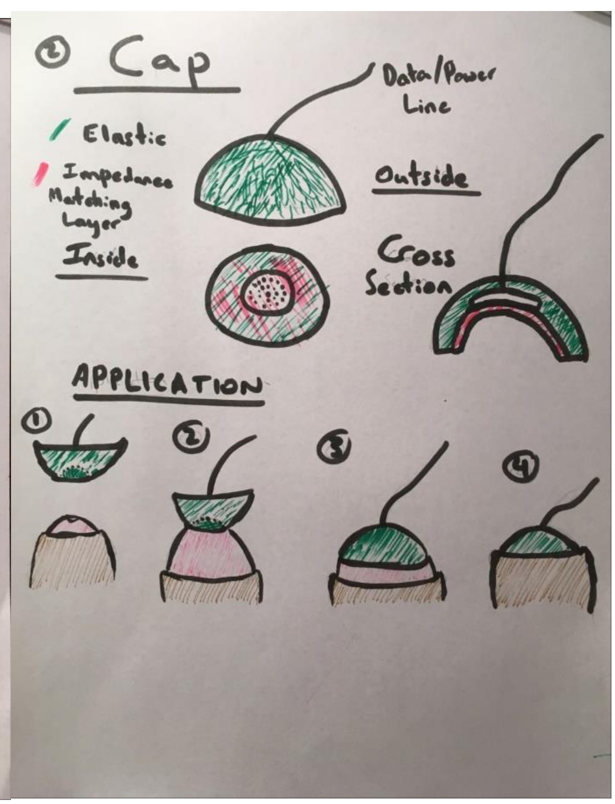


Finalizing designs, Elastic Band and Cap chosen:

Elastic Band



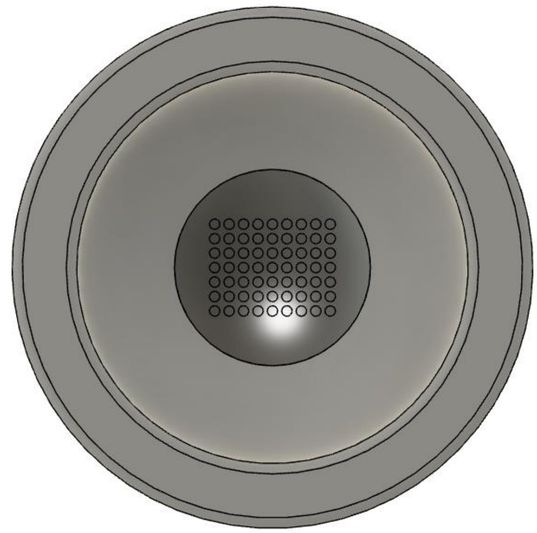
Cap



CAD of Final Deliverable:

Cap, designed for attachment to the glans penis

Full design, bottom-back view

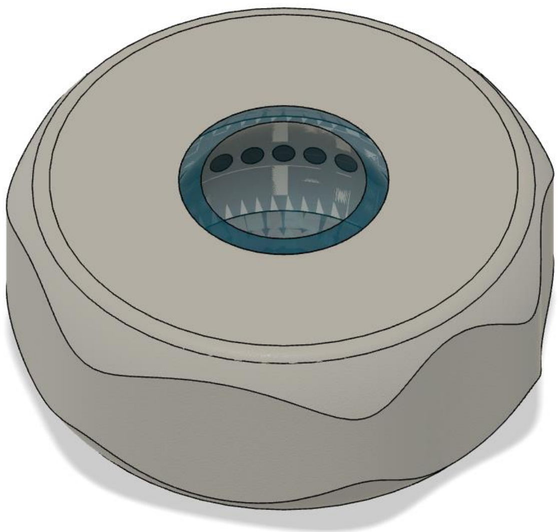


Impedance-matching layer removed, bottom view

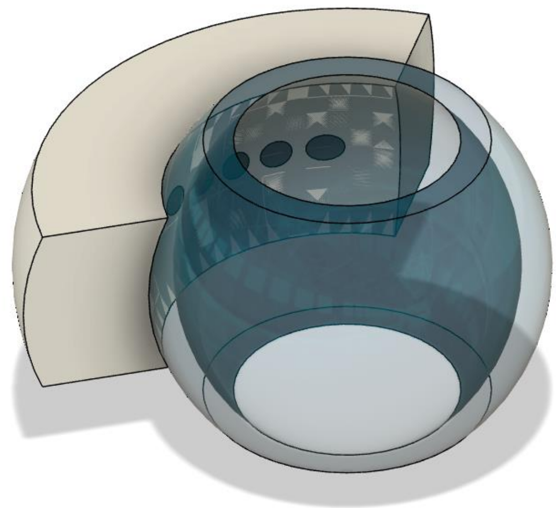
9 x 7 Ultrasound transducer array in center

Full design, front view

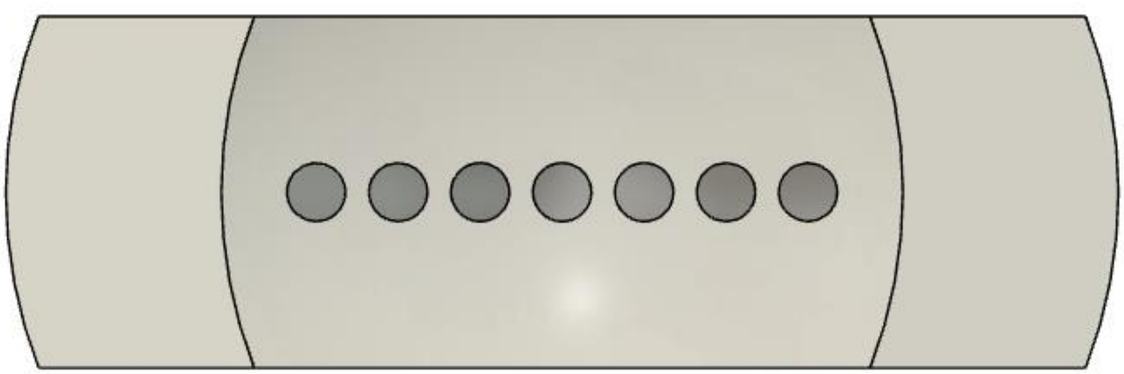
Elastic Band, designed to slide on and rest at the base of the penis



Full design, bottom-back view



Outside elastic layer removed, isometric view



Ultrasound Transducer Array Component, Front View

Linear 1 x 7 Ultrasound Transducer Array in center

ExiTrak

August 2019 – December 2020

University Final Project for Biomedical Engineering – Group Project

Descriptive Paragraph:

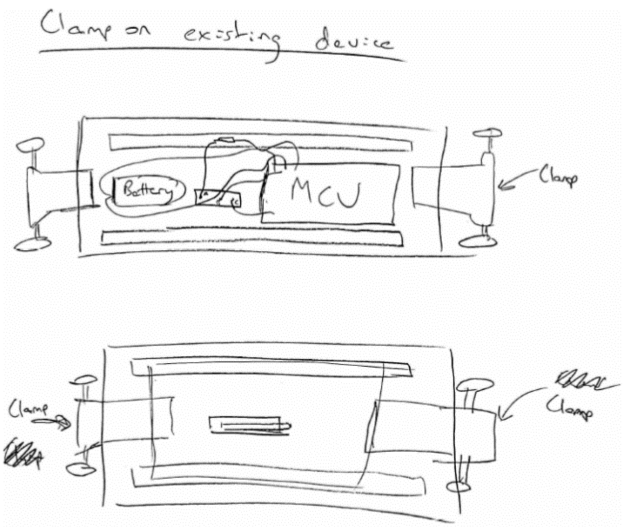
The towns of Welch and Williamson, West Virginia, have been economically devastated by the coal industry's disappearance from West Virginia in the later part of the 20^{th} century. This economic crisis, compounded with a high incidence of COPD, heart disease, and diabetes in the region has created a health catastrophe: citizens cannot afford curative measures for their dangerous ailments. To address the growing need for healthcare, community health workers in these towns have prescribed exercise program for patients to perform in their homes using exercise bands. These exercise programs can dramatically improve patient outcomes, and the community health workers want to have a way to track patients' exercise, both to ensure the patient is following their prescribed exercises, and to gauge the program's success. Our design group inherited the project from a team who worked on it the prior semester and failed to create a successful product: their failures were due to faulty software and a poor mechanical design, the device had no securing mechanism to the resistance band and after a few stretches was unable to record any future stretches. We improved their mechanical design, fixing the problem of securing the band with a clip and improving the user ergonomics with a handle, and wrote an energy efficient software package using Python for the device's operation. My contribution to the effort was writing all the Python code which operated the device, brainstorming mechanical designs, and assembling the device. Our finished product could record up to 10,000 stretches per day for up to a month before the batteries had to be replaced. User research was also performed with the finished device, our group tested the public's acceptance of the device and the device's ease of use by asking ten Duke students to use the device after having read instructions, and the device passed all testing: users gave the product an average of 4.0/5.0 stars, and after reading instructions, successful stretches were performed by students in under a minute in all cases. Note: I completed some of the mechanical design work, pictures with no attribution are my work, I attribute the work of authors underneath the pictures.

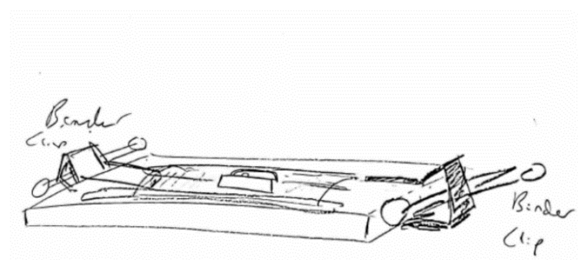
Level of Project: Fourth year (7^{th} semester)

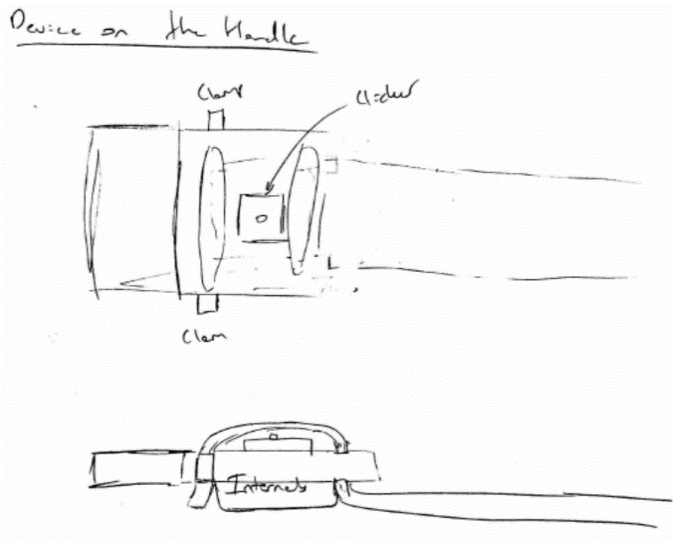
Name of supervisor of project: Dr. Robert Malkin and Dr. Allan Shang

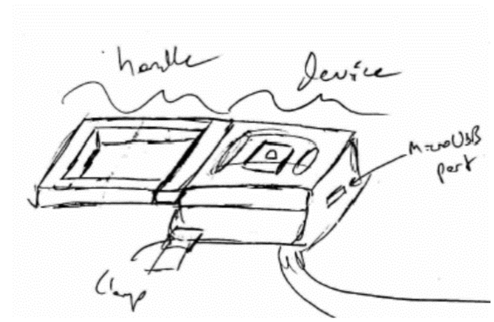
What we were given:

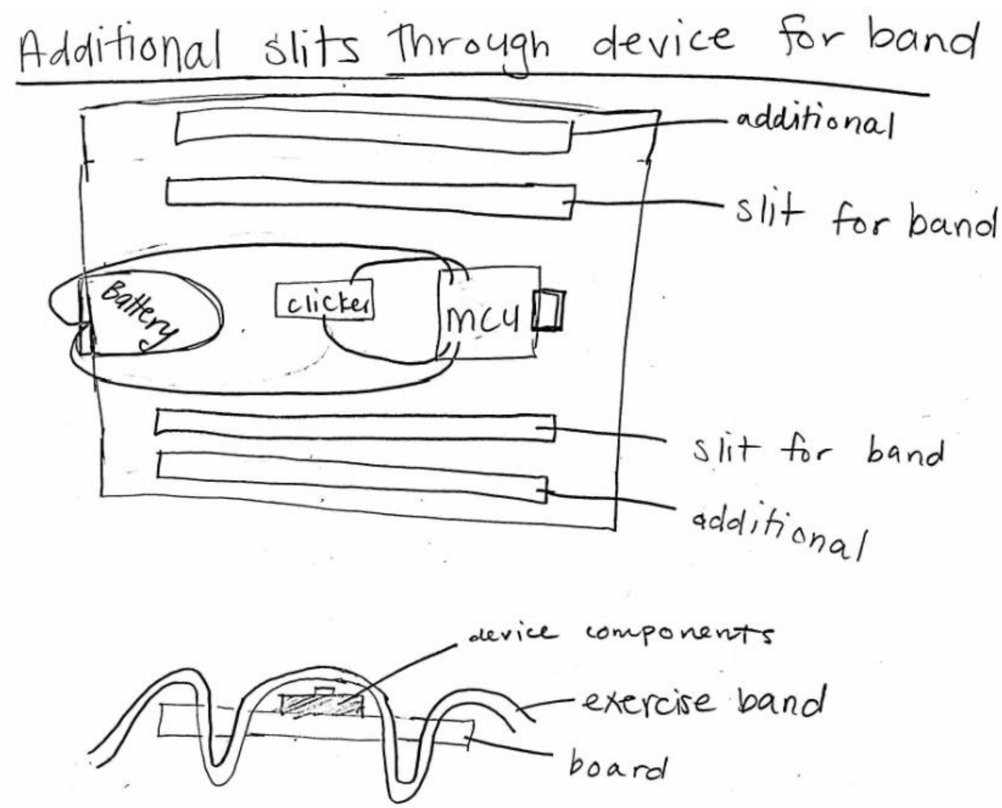
Improved Mechanical Design Iteration Sketches with labelled titles:







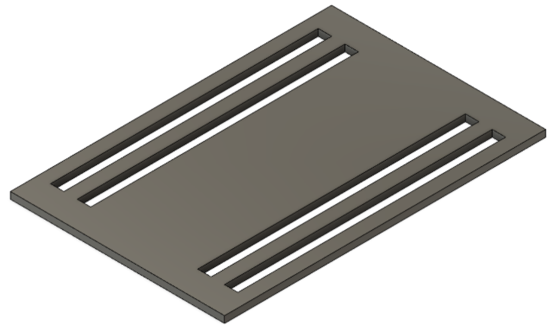




Author of ‘Additional slits through device for band’: Madeline Manning

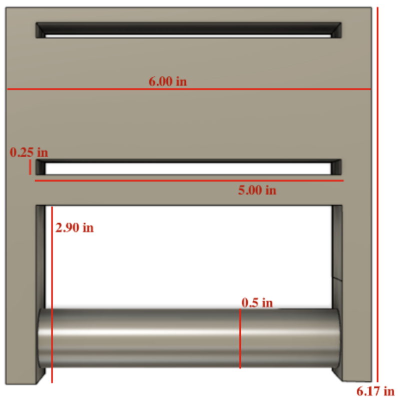
CAD Models for 3D prints:

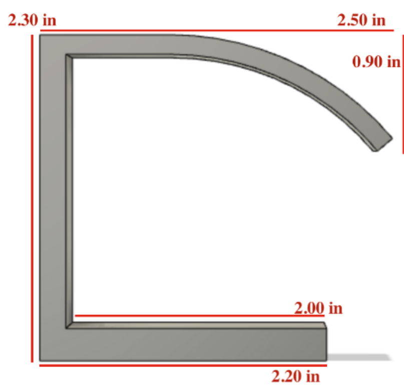
First Iteration of Handle Design

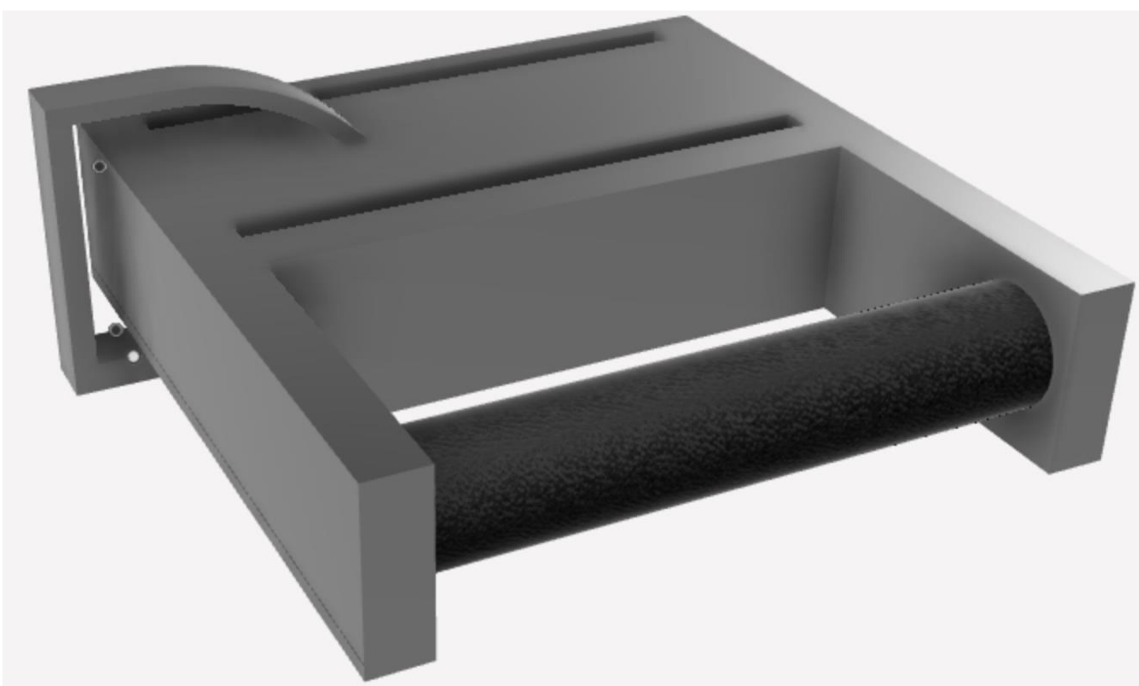


First iteration of double slit design

Final CAD Design decided on after handle performed best on accuracy testing:







Author of rendered handle design in CAD: Qarch Hawk

Assembled ExiTrak Final Design

Pictured: User performing bicep curls and butterfly stretches

EquinOx

January 2020 – April 2020

University Electrical Engineering Final Project – Individual Project

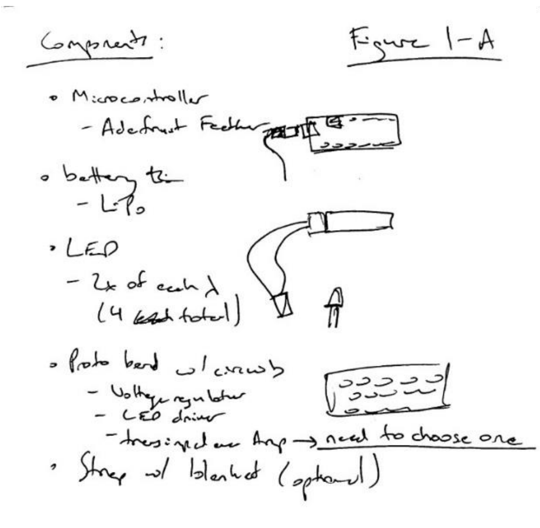
Descriptive Paragraph:

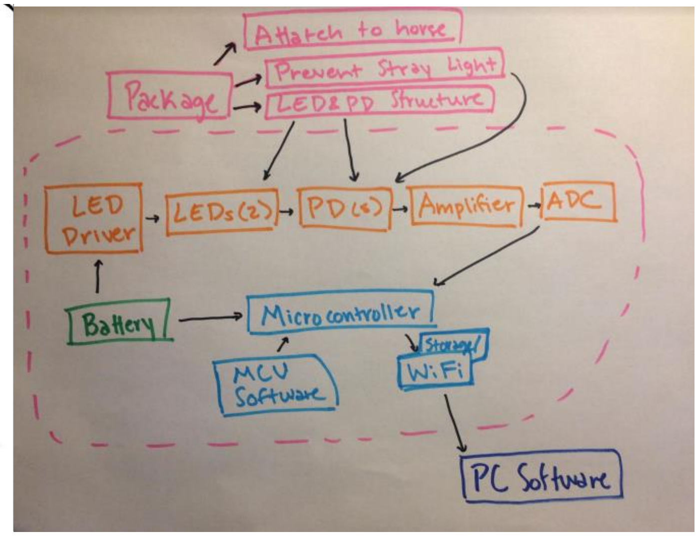
Horses can go from healthy to fatally ill in the matter of an hour from a condition called colic, a blockage of the intestines. In a study done by the US Department of Agriculture in 2001, it was found that there is an average of 4.2 colic events / 100 horses in a year, with an 11% fatality rate for each colic event. This is a deadly fact of life for horses, and horse owners are willing to go to extreme lengths to protect their investments: in total, $115 million was paid by horse owners for colic surgery in 1998. There is a real need for health monitoring technology for horses that will notify horse owners if the horse is having a colic event so that they can contact the veterinarian and intervene in time to save their horse's life. For this reason, my mentors, Dr. Brooke and Dr. Jokerst, and I are collaborating with the North Carolina State College of Veterinary Medicine to make this product a reality. Our plan is to build a reflective pulse oximeter that is wearable by horses. This device will monitor the horse's blood oxygenation levels and will notify the owner over a Wi-Fi connection if the horse's blood oxygenation levels dip below a defined threshold, a symptom of colic. With this product, I hope to save more horses from excruciating deaths and to give the horses' caretakers the peace of mind that wherever they are, they will always know their horse's health. Dr. Brooke, Dr. Jokerst and I designed the hardware layout of the device together, and I designed the mechanical attachment of the device to the horse individually. After the coronavirus epidemic cancelled classes, I had to restart the project from home because I no longer had access to the campus resources. As a result, the photos shown are of a rough mechanical prototype, I am still working on completing the final version that will be used by the North Carolina State College of Veterinary Medicine. All the work shown below is mine. No user research was done on horses because testing on horses was not included as part of the grant.

Level of Project: Fourth Year (8^{th} semester)

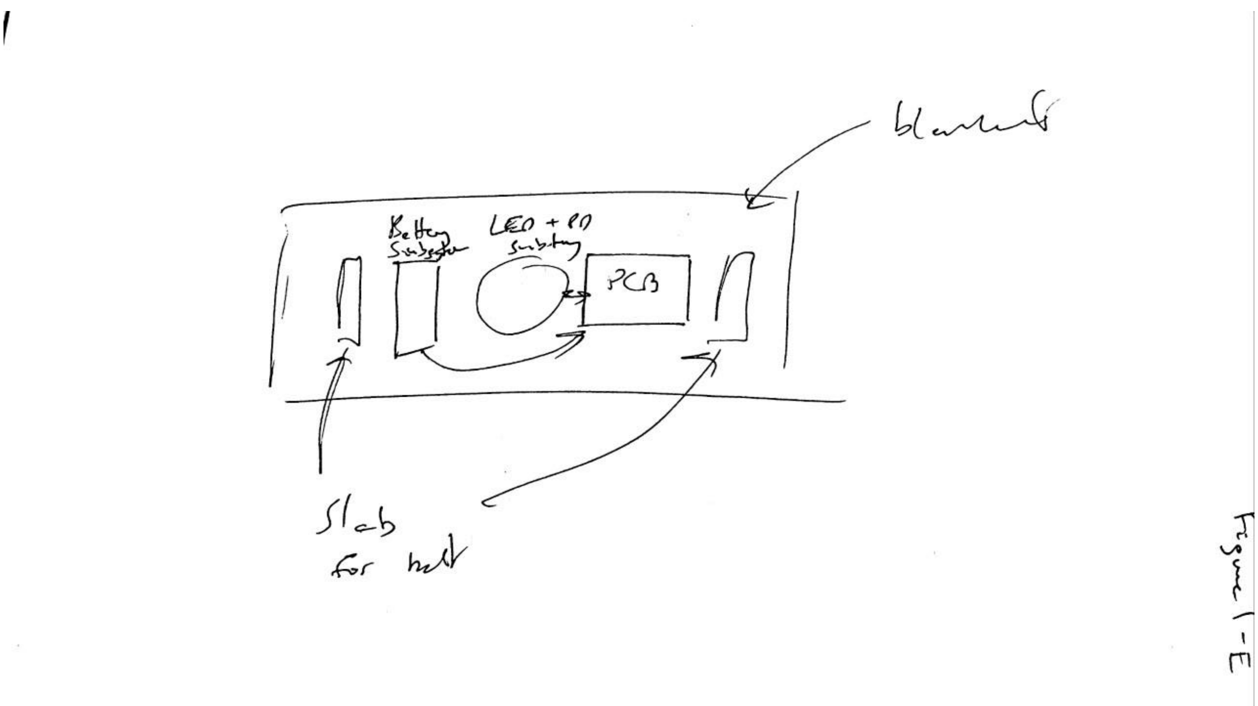
Name of supervisor of project: Dr. Martin Brooke and Dr. Nan Jokerst

Identifying and Organizing the system components

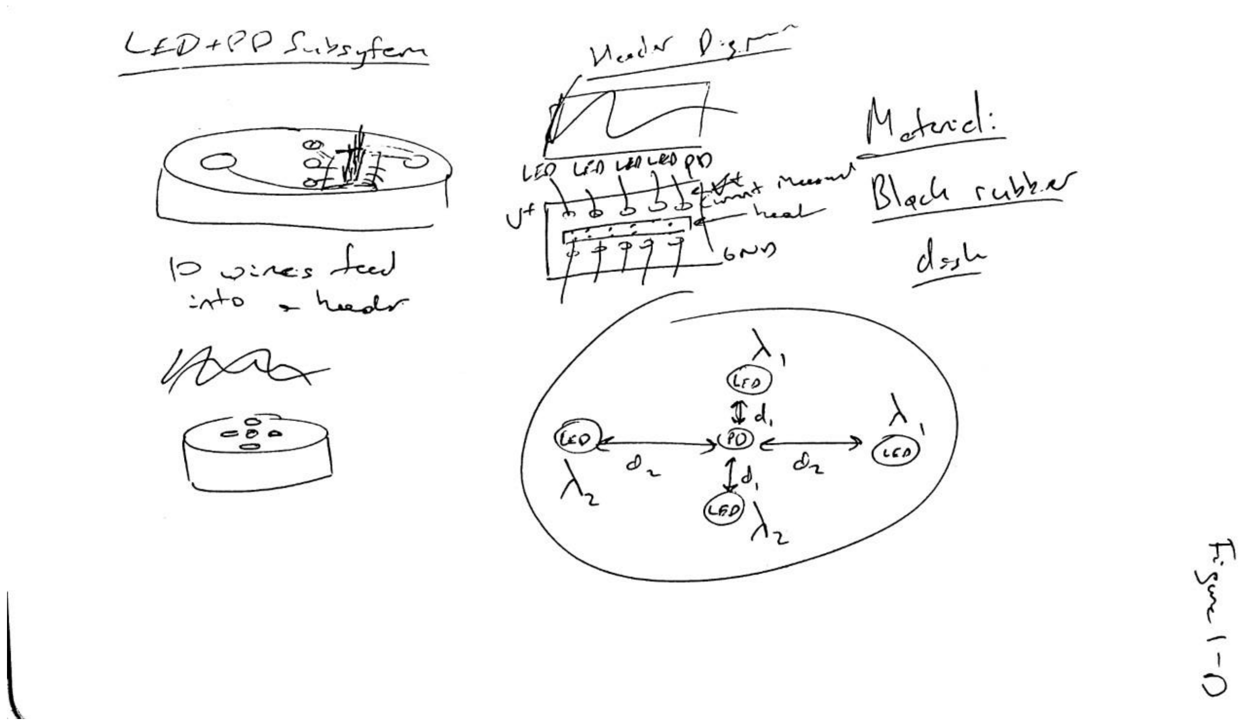




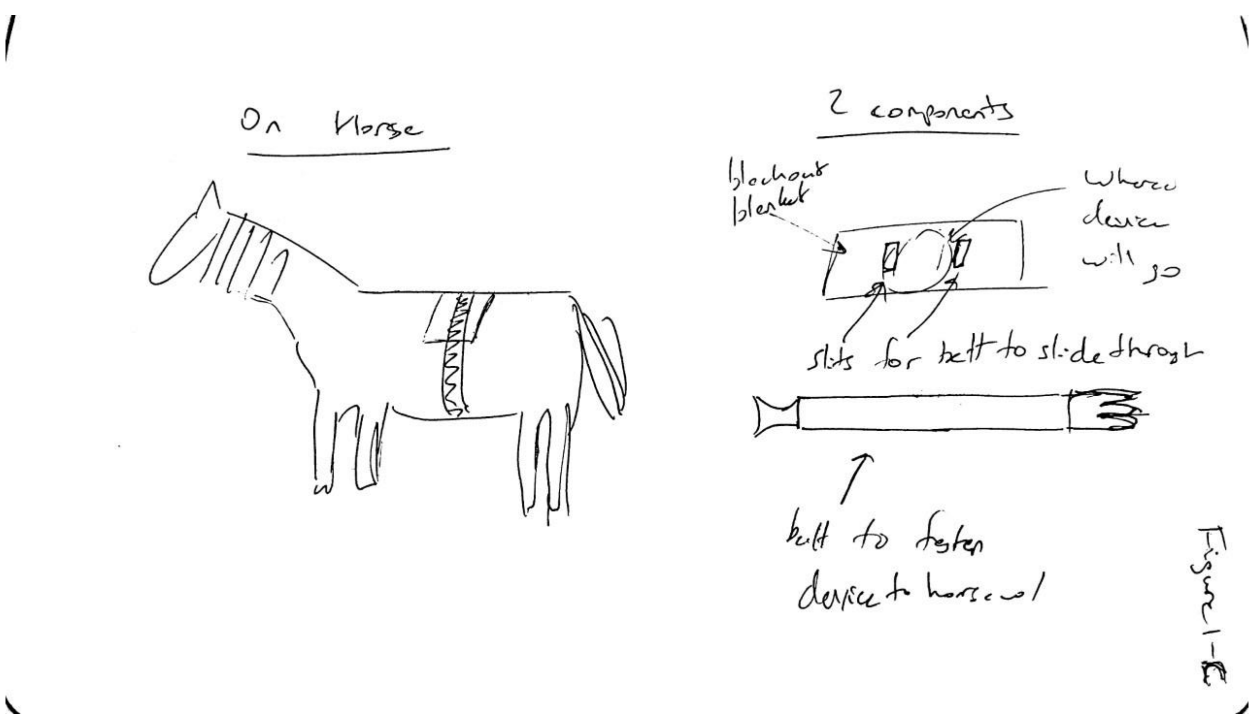
1st iteration of planned attachment of device to horse saddle blanket components sewn under fabric



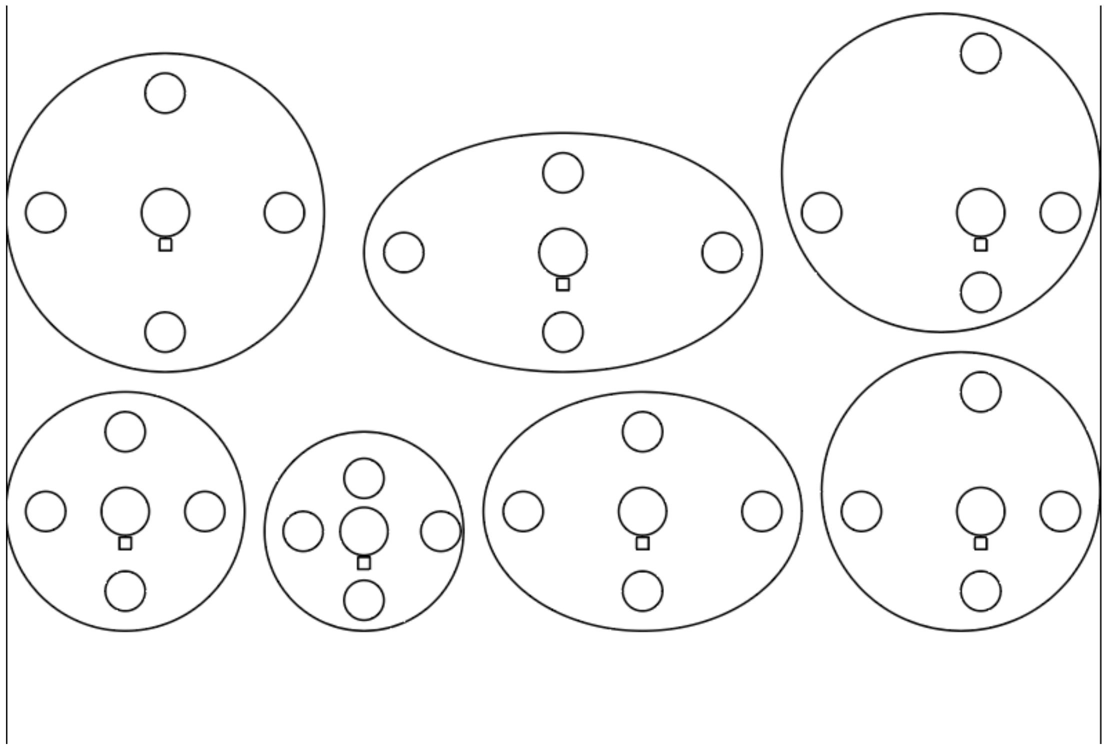
Sketch of 1st iteration for planned holder for the LEDs and Photodetector: they must be flush with skin for accurate measurements



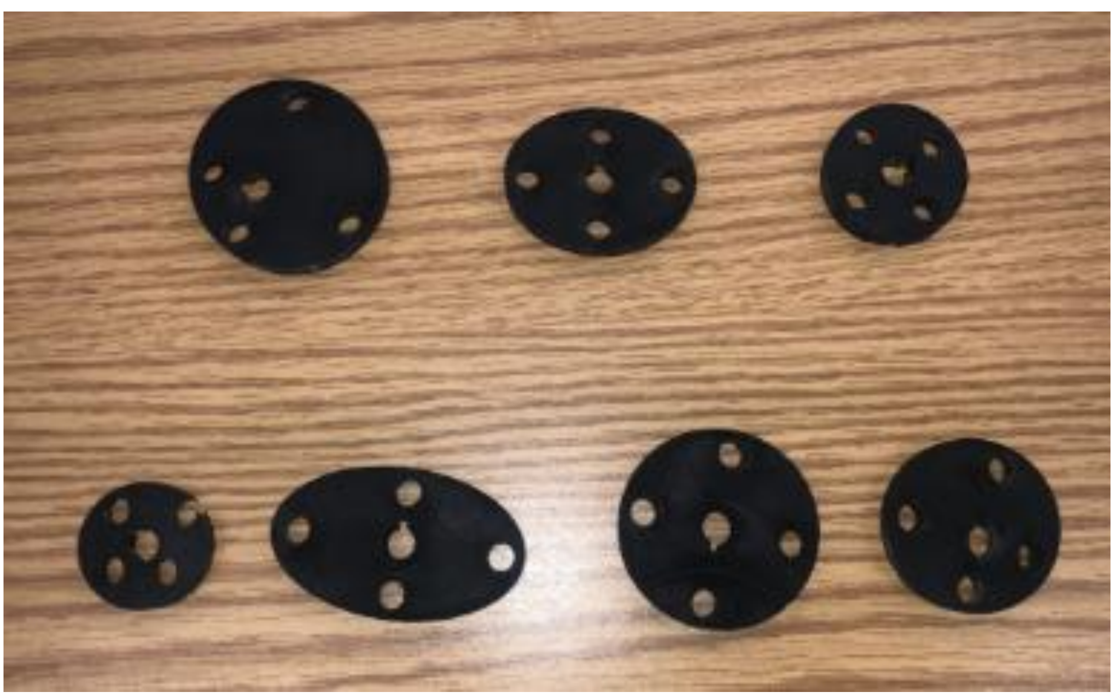
Sketch of device's appearance on horse; explanation of attachment of saddle blanket through strap



LED and Photodetector case layouts (photodetector is in central hole, 4 LEDs in surrounding holes): each has different depths of penetration for measuring the blood oxygenation levels of different types of blood vessels

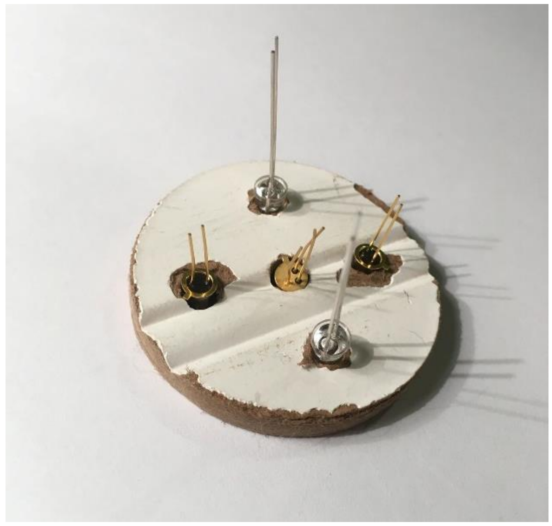


1st iteration: Laser Cut Rubber (smelly!), decided to switch to odorless Teflon for final version, but classes were cancelled before this could be implemented



Rough Physical Prototype created at home

Wood used for LED and photodetector case; LEDs and photodetectors placed with leads out

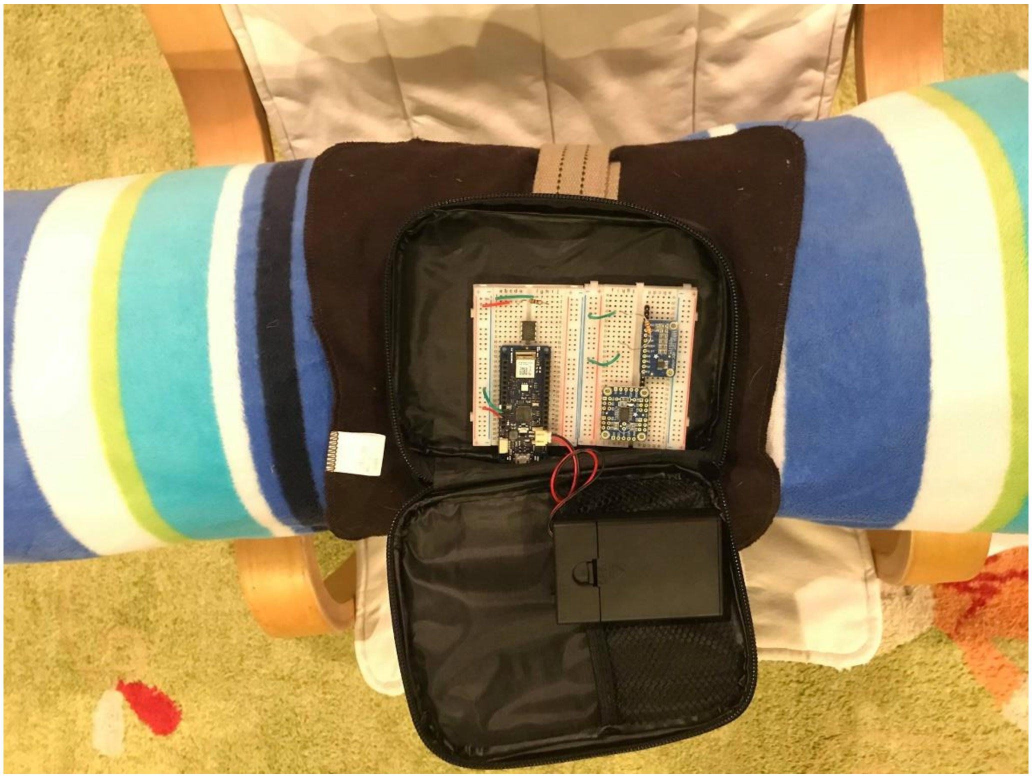


Black, light-absorbing saddle blanket with strap bottom-up, LED and photodetector case attached on bottom of blanket as seen in sketches

Prototype attached to pillow to simulate being attached to a horse, side view

Prototype attached to pillow to simulate being attached to a horse, top view

Prototype attached to pillow to simulate being attached to a horse, top view with electronics case open



Prototype attached to pillow to simulate being attached to a horse, isometric view

MedAware

February 2020

Individual Project – Reimagining Group Hackathon Project as an Industrial Design Exercise

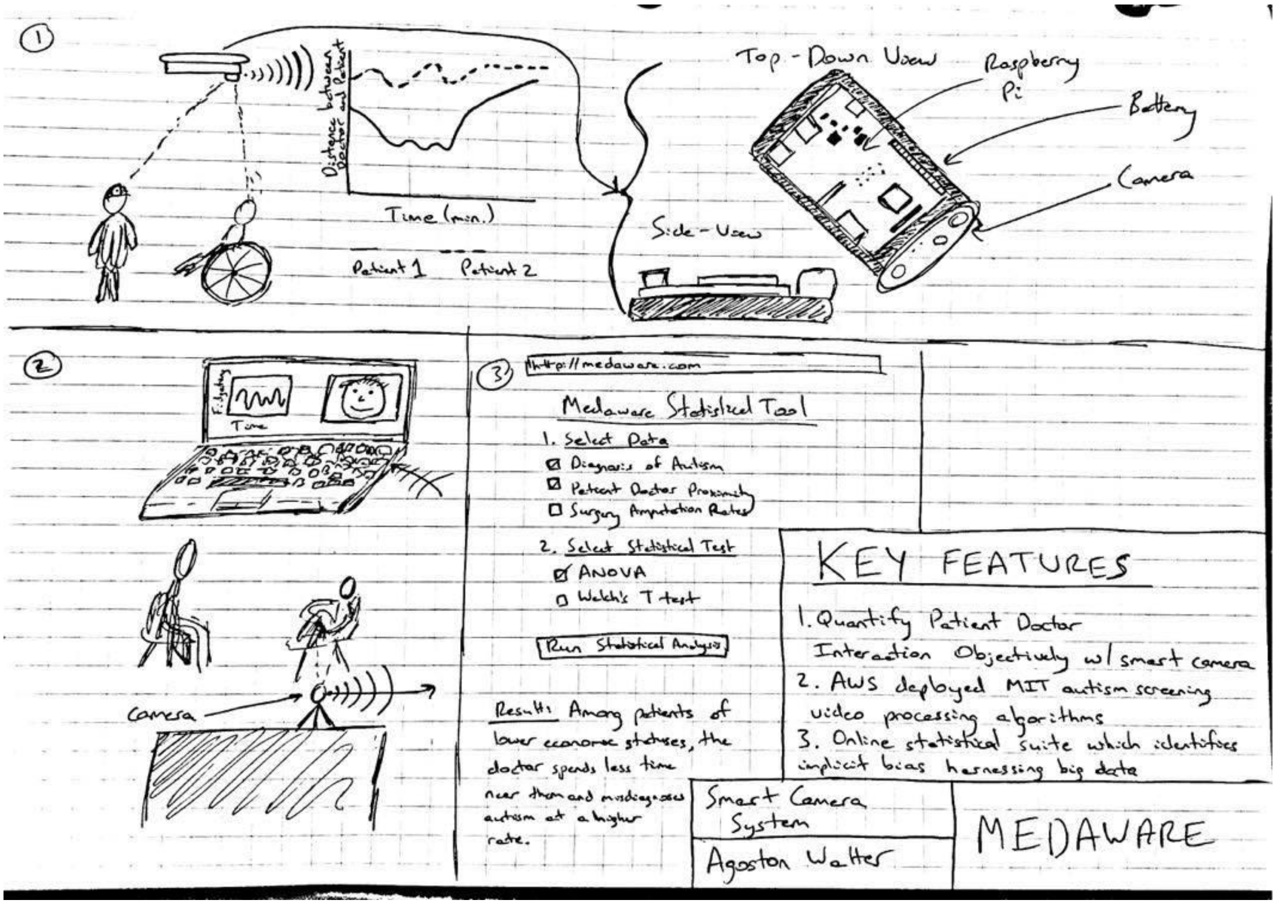
Descriptive Paragraph:

Implicit bias kills in the United States healthcare system. There have been studies published that have established that implicit bias from doctors towards their patients can prove to have fatal consequences by showing that certain demographics have patterns of worse health outcomes than others when treated for the same ailments. My team won John Hopkins University's Medhacks 2019 by pitching MedAware, a suite that physicians and hospital management can use to track and quantify doctors' interactions with their patients, in hopes of educating health care providers of their implicit biases and improving their quality of care. Please visit the following link to learn more about the original project: https://devpost.com/software/medaware. The software and hardware components developed by myself and my team are ready to be implemented by hospital systems, but the design of the camera system can be rethought to be more user friendly and less obtrusive in the doctor's office. As an exercise of my industrial design skills, I decided to see if I can think of a better form factor that will fix the aforementioned problems with the original design.

Level of Project: Fourth Year (7th semester)

Name of Supervisor of Project: N/A

Complete Product Explanation:

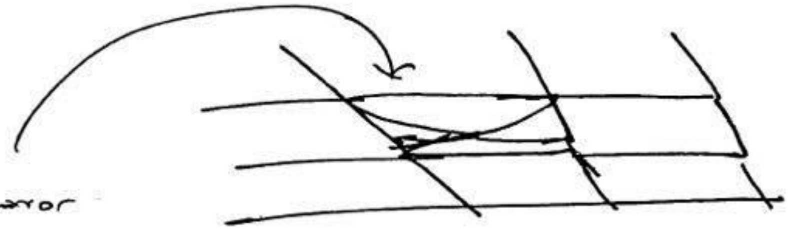


Original Design: clunky mechanical design and scary for patients in the clinic to see a camera

May give the feeling that Big Brother is watching…

Exploration, brainstorming kind of form factors can we solve this issue with

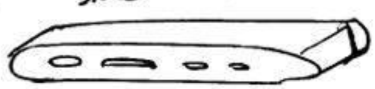
Exploration:

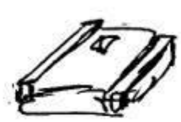


One-way mirror ceiling tile

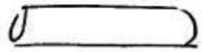
Constraint: needs to be facing down towards patient/doctor (needs to be 90° to ground

Smart Camera



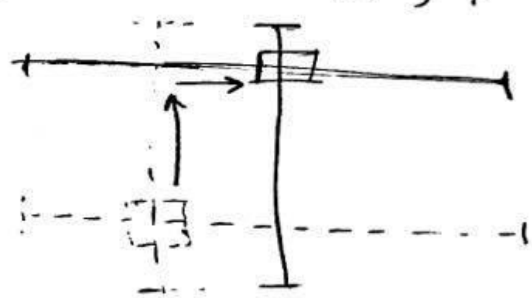


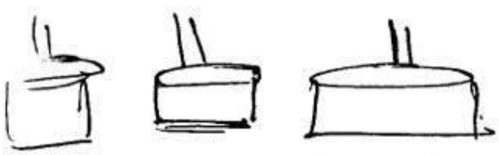
Raspberry Pi



battery (optional)

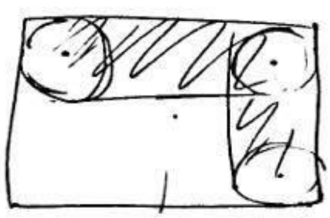
What if room is too big for camera lens?

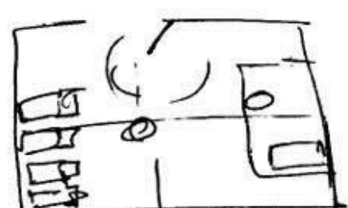




Multiple lights that cover whole room w/ camera in each one.

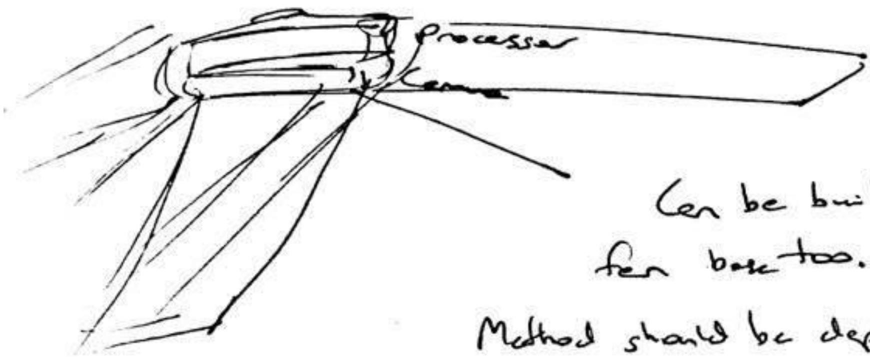
Very conspicuous (or have a complete ceiling made from one-way glass)





Camera system that moves along central axis at other x/y direction

Continued exploration, transition to idea of hiding in plain sight

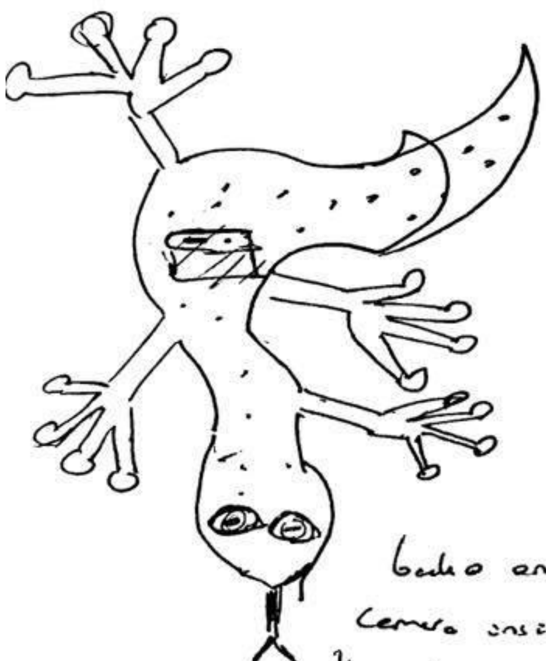


Can be built into fan base too.

Method should be dependent on clinic.

Can be conspicuous but cute!
-kid friendly

Camera interface inside plug in toy sitting next to doctor



Gecko on ceiling,
Camera inside, facing down through a one-way section,

Goal identified after analysis of exploration: either hide the camera or make it friendly!

Multiple options for different audiences:

~~Abstract art for~~ kids

~~- pieces of~~

Hide in plain sight:

- animals for kids + adults (elephant/giraffe sitting, gecko on ceiling)

~~Abstract board for adults horizontal /~~

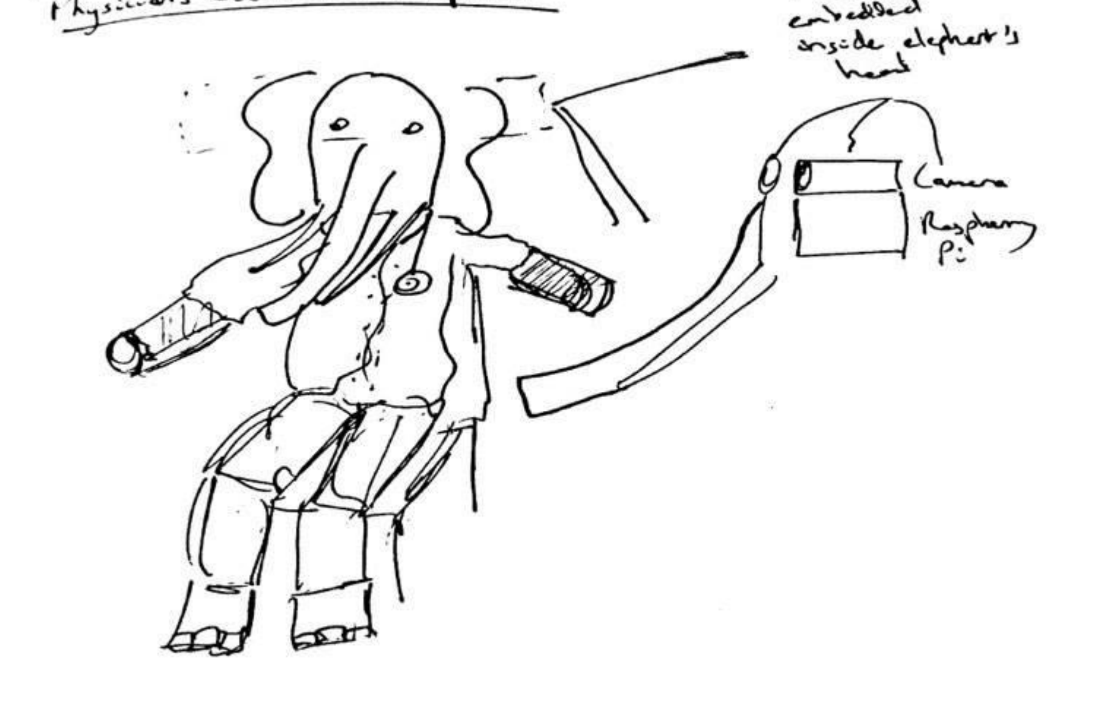
Just hide

- don't need to optimize for audience
- place in light, ceiling tile
- place in fruit bowl, radio

Goal: turn something scary either into something not seen or into something friendly

Friendly Form Factor:

Physicians assistant Elephant

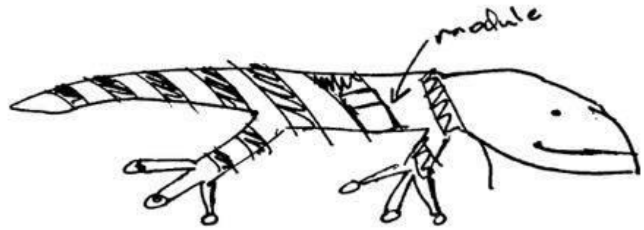


Continued Friendly Form Factors

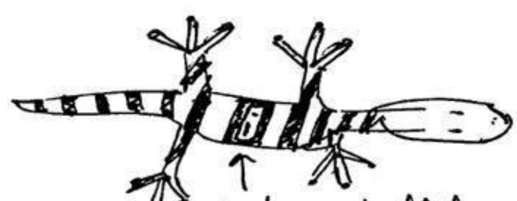
Idea Sketches:

Tiger gecko for ceiling:

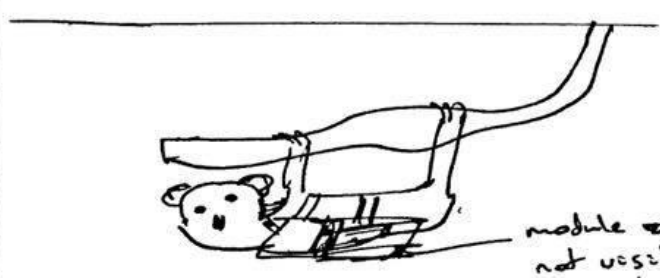
Side View



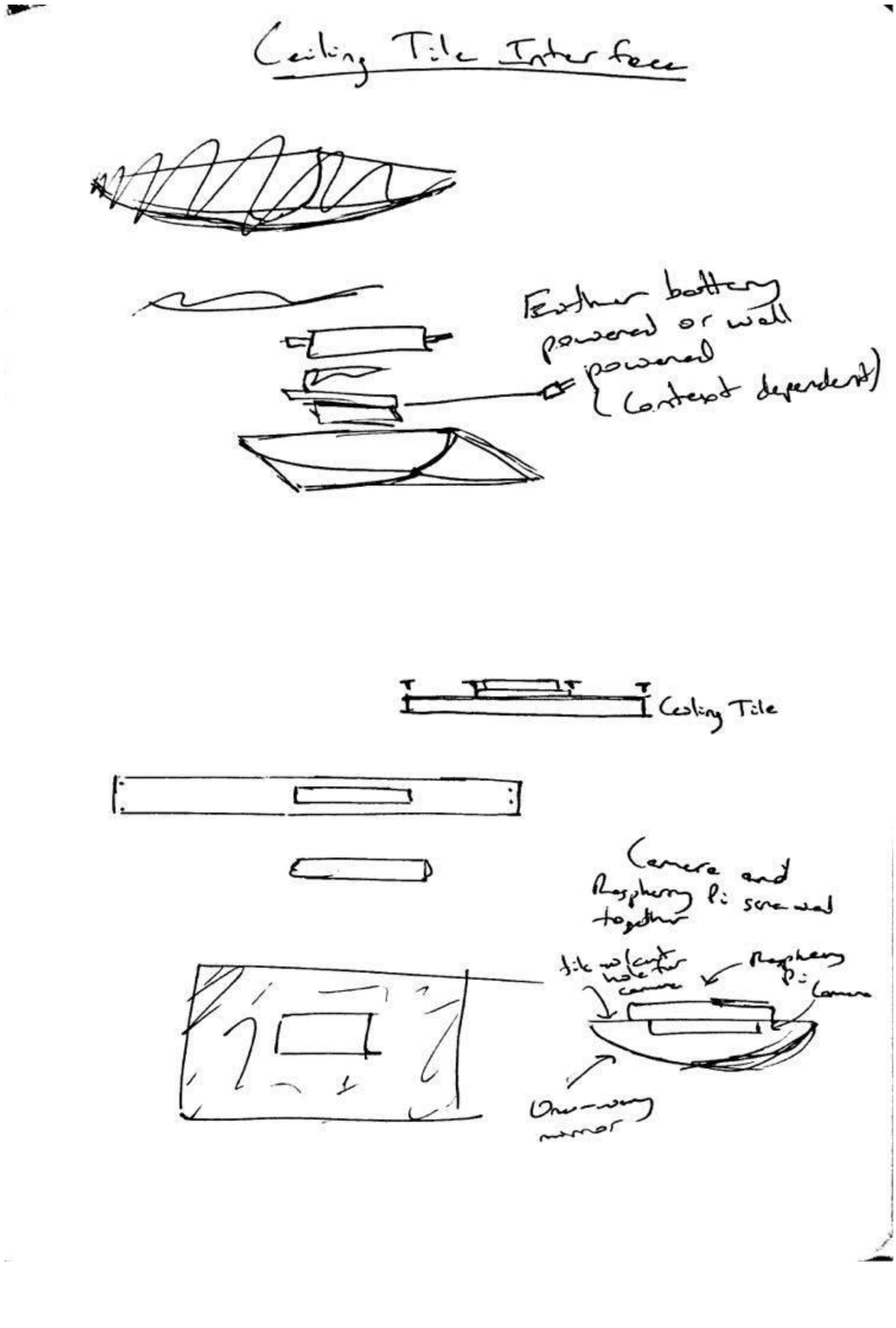
Top View



Koala/ Sloth for ceiling



Hiding the Camera: One-Way Mirror Ceiling Tile



Hiding the Camera: Light Interface