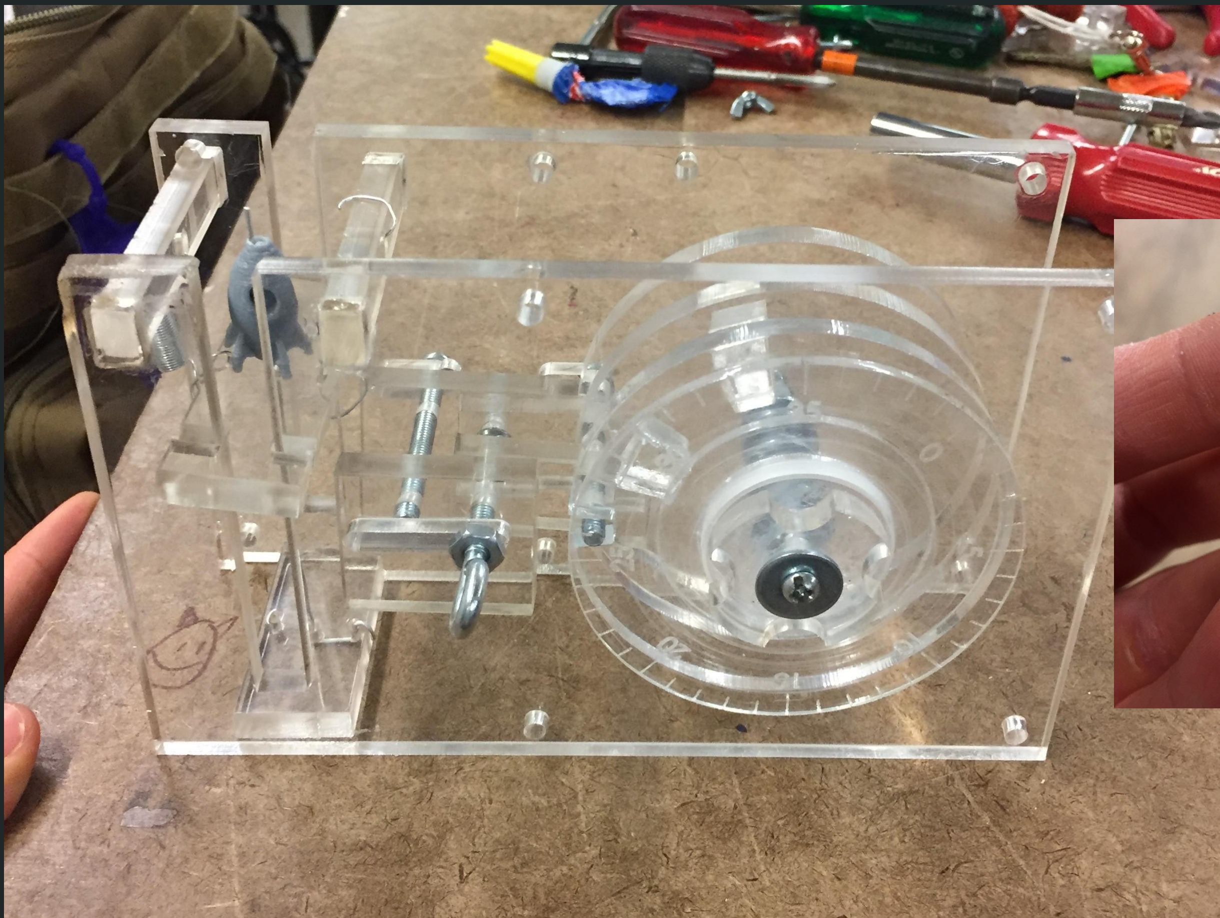
Project Portfolio

Haley Higginbotham

For a more extensive record of my works please refer to my website at:
https://hhigginb.github.io

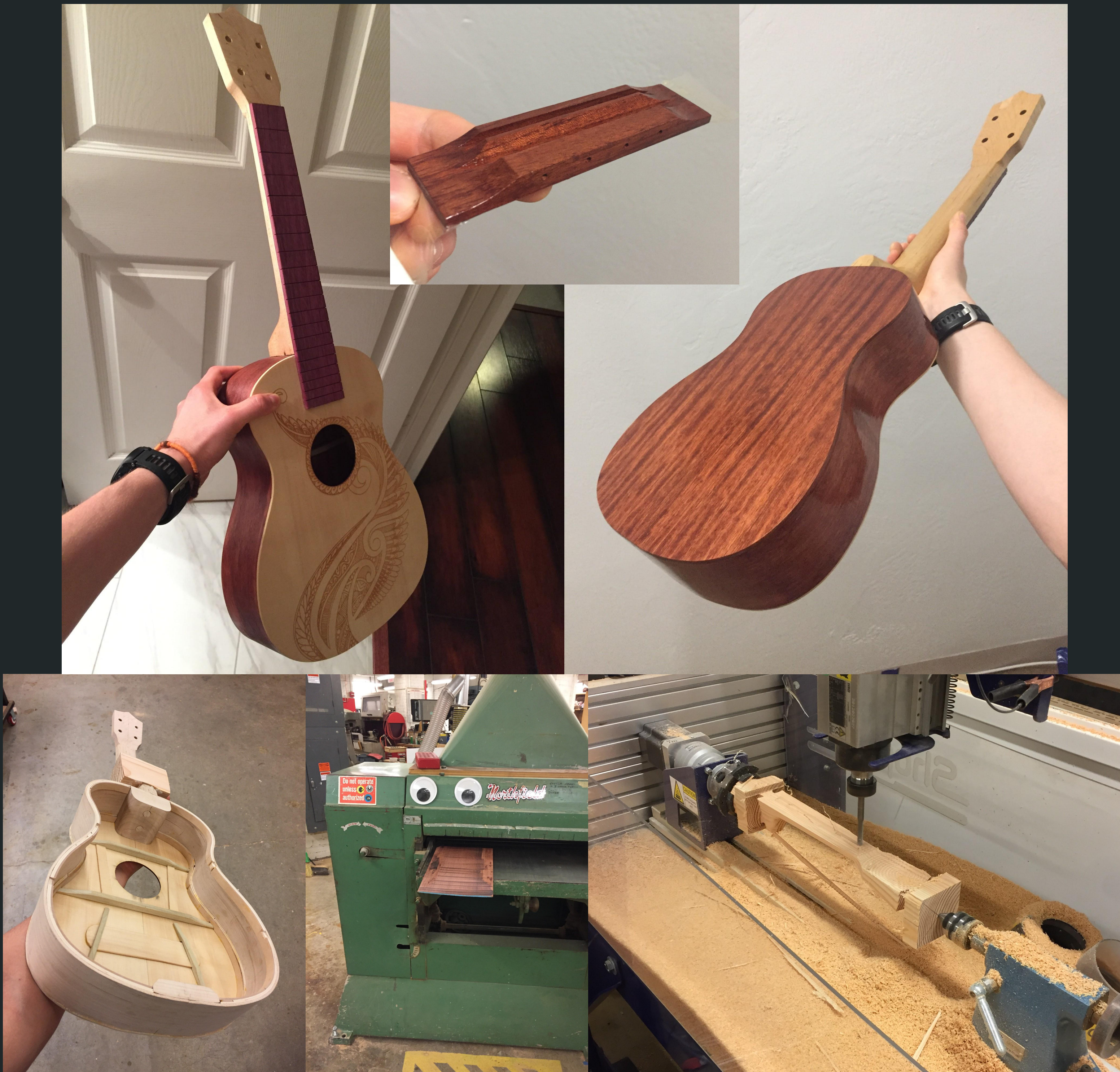
ComboLock/Launcher



The combination lock is an common item that is often overlooked, but beneath the simple exterior is an intricate and complex array of interacting parts. Fascinated by these inner workings, I decided to fabricate a clear combination lock so that the mechanism could be on full display during use. Thus the Combolock Launcher was born.

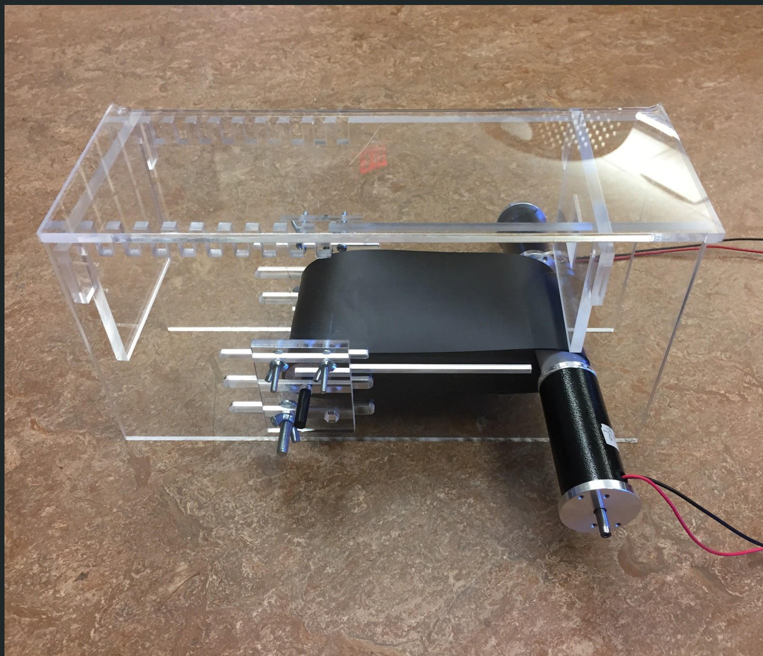
I laser cut the bulk of the lock from clear acrylic. It took some iteration to get the dimensions right due to the kerf of the laser. I also had to design the inside to minimize friction between the axle and wheels - so the wheels would only turn when contacted by each other. In the final design, rather than having the lock open a safe, I had it pull a release to trigger a spring-loaded platform. When the proper launch code (the lock combination) was input, the platform sprang up to launch a 3D printed rocket into the air! As a fun bonus feature, I designed the notches and protrusions on the inner wheels to correspond to a launch code of 32-8-15 (the postal code for the Kennedy Space Center). I made the rocket small and light and the springs are quite compressed in the starting configuration, so the rocket launches so high it hits the makershop ceiling!

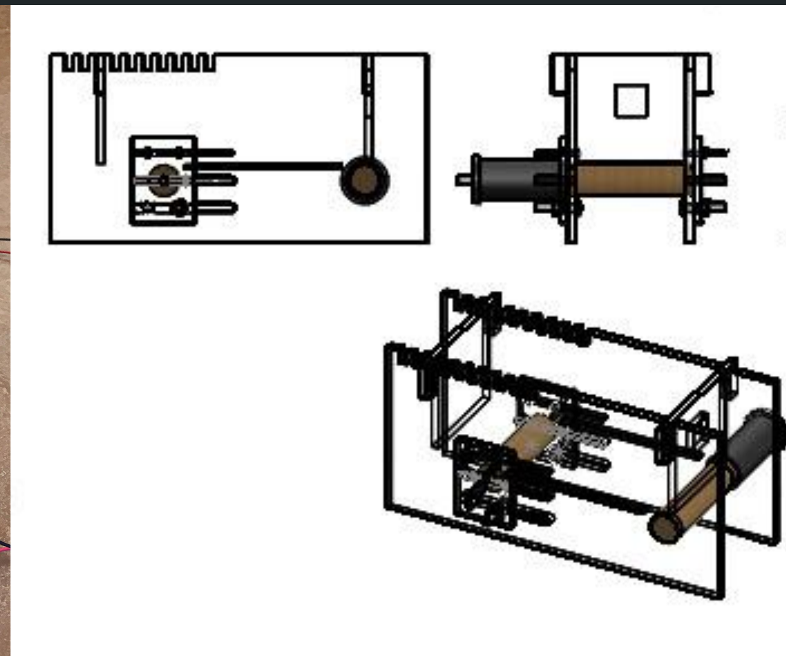
Ukulele



While WWOOFing (World Wide Opportunities on Organic Farms) in the Los Padres Mountains I learned to play the ukulele and decided it would be a fun challenge to build one of my own. I spent the vast majority of the 2020 Fall semester in MIT's Hobby Shop, and I am currently putting the finishing touches on this project!

Rat Treadmill





My project in the Bioelectronics Group, evolved over a couple years and involving a great host of subprojects. The overarching project investigated the potential for light to induce neuro-regeneration in rat models of spinal cord injury. I was initially recruited to design and build a rat treadmill for assessing the recovery of locomotor function. I was responsible for the entire development process, from background research, to design, fabrication, and testing. I created CAD models and fabricated my designs with a laser cutter and lathe. I also sourced and tested motors and elastic belt materials to optimize cost and performance. I iterated on the treadmill multiple times based on testing results. For example, in one early version of the treadmill, the belt was prone to slipping off of its track. Through researching related fields, I was able to identify and implement a solution - creating a convex surface for the belt pulley to generate differential tensions resulting in a self-centering system. This experience was great practice in the engineering design process, from ideation to fabrication and iteration.

Within this group I also:

- Aided in the fabrication of custom neural probes
- Implemented a cloud-hosted neural network to perform motion capture video analysis

Auditory Feedback with the MANUS Robot

My freshman year I managed to get a position in the Newman Biomechanics and Rehabilitation Lab. In this project I adapted a user-machine interface program to process motion parameters into auditory output for an investigation into feedback-mediated locomotor control.

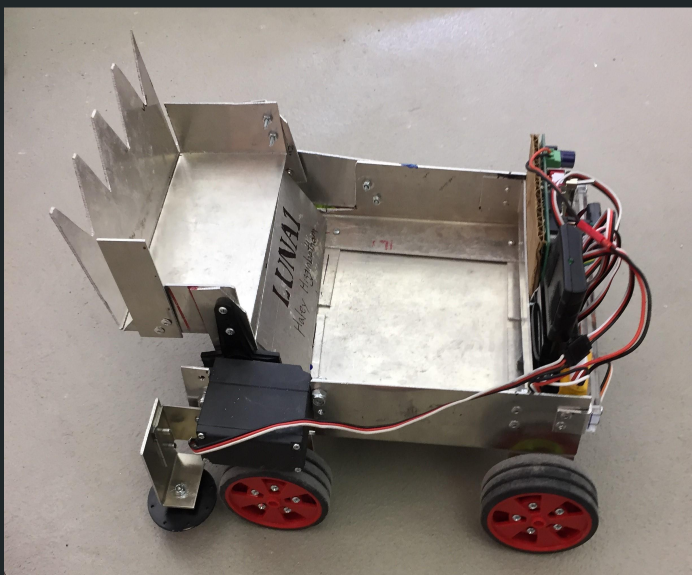
To do this I had to first learn LabView - a software used to adapt the robot's FPGA controller. The investigation of auditory feedback was inspired in part by the motor control of musicians so, after developing the needed coding skills and adapting the feedback program, I created CAD models and 3D printed handle adaptations so users could grip the robot handle like a violin bow.

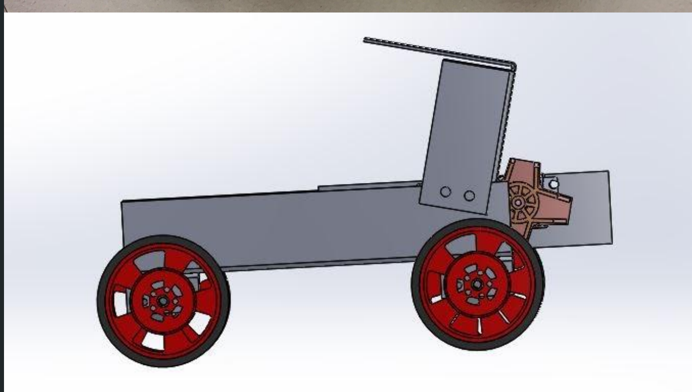
I then collected some initial data, analyzed my findings, and presented to a joint lab meeting with collaborators at Northeastern University.

Multi-Gym

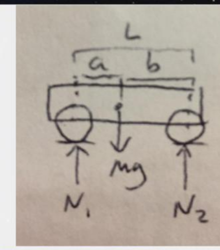
While working on a farm in the Los Padres Mountains, I built a squat rack/multi-purpose gym. The farm I worked on was rich with piles of scrap wood, steel, and other seemingly random things. When I finished my work for the day, I was able to venture through the scrap heaps and let my imagination run wild. I used 2x4s for the main frame of the rack, created knee braces from plywood, and used steel water pipes for the pullup bar and crash bars. I then added some pulleys I found to make the rack even more of a multi-purpose gym. The pulleys I found were perfect since they could just slide right onto my crash bars, enabling the height to be adjustable. At first I just slung buckets of rocks onto a water pipe to use as a barbell. The swinging of the buckets provides for some added stability work! We had some leftover concrete from a job in town though so I then poured some plates as well. Instead of a typical collar I screwed on detachable angled sections of pipe to prevent the plates from slipping off the ends of the main pipe (barbell).

2.007 Lunar Robot





Technical Calculations



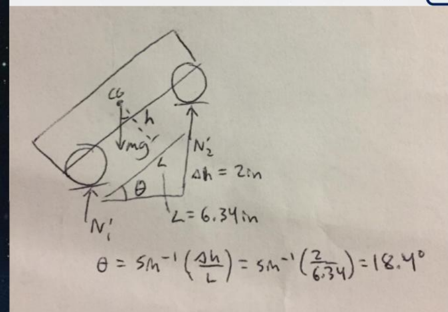
CG:

$\Sigma M = 0 \rightarrow N_1 a = N_2 b \rightarrow b = N_1 L/(N_1 + N_2)$

$N_1 + N_2 = m \rightarrow b = N_1 L/m$

N(left wheels) = 0.794 kg → $\boxed{\text{0.122 m from right wheels}}$

N(back wheels) = 0.624 kg → $\boxed{\text{0.067 m from front wheels}}$

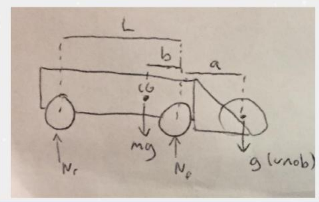


$h = (N_1' - N_1)/(mg) \quad {}^*L^*\cot(\theta) + r$

$= (0.709-0.624)/1.5 \; {}^*0.161\text{m}^*\cot(18.4^\circ)+0.035\text{m}$

$\boxed{h \approx 0.035 \text{ m}}$

More Math!



Torque:

@ tipping Nr = 0

$\Sigma M = 0 \rightarrow$ (unob)a > mb → $\boxed{0.1005 \text{ kg*m} > 0.054 \text{ kg*m}}$

T required = (unob)ag = 0.095*0.569*9.81 = $\boxed{0.53 \text{ Nm}}$

VS-11: @6V = 1.9 Nm → T provided = 5/6(1.9) = $\boxed{1.58 \text{ Nm}}$

SF = 3x!

Power budget:

1 Lipo

0.5 Ah * 7.4 V	3600 s = $\boxed{13.32 \text{ kJ} < 30 \text{ kJ}}$
1 h	

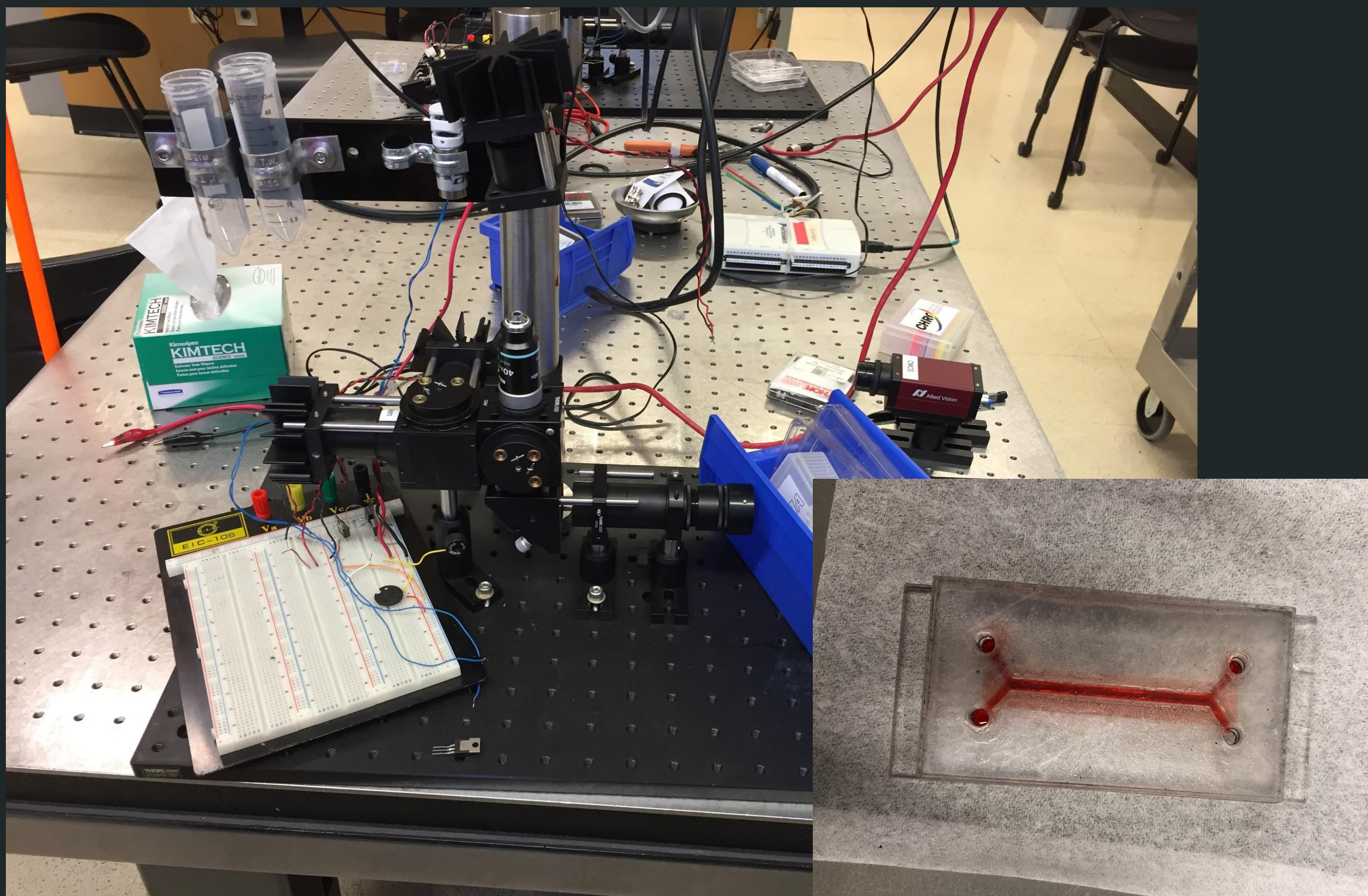
In my sophomore spring I took 2.007 (Design and Manufacturing I). This was definitely one of the most fun classes I have taken. Each student designs and manufactures their own robot to perform various tasks at an end-of-course competition. My design was grounded in center of mass and friction calculations and digital models of component geometries. I spent the semester in the machine shop, prototyping and iterating. To illustrate, one fun challenge was preventing the edge of the robot from catching on the edge of the gameboard while climbing a steep slope. I looked around the shop and threw together a side-mounted wheel from spare parts to create a rolling contact; it worked perfectly! I was excited to see my creation advanced to the quarter-finals and had the honor of receiving an end-of-course award for design and execution. The greatest satisfaction though of course was in how the practical experiences of the class had deepened my understanding and abilities in engineering.

Glassworking

Top: Octopus - action shot
Bottom Left: Turtle with Inlay
Bottom Right: Tropical Fish - all the colors and features made this especially fun to make!

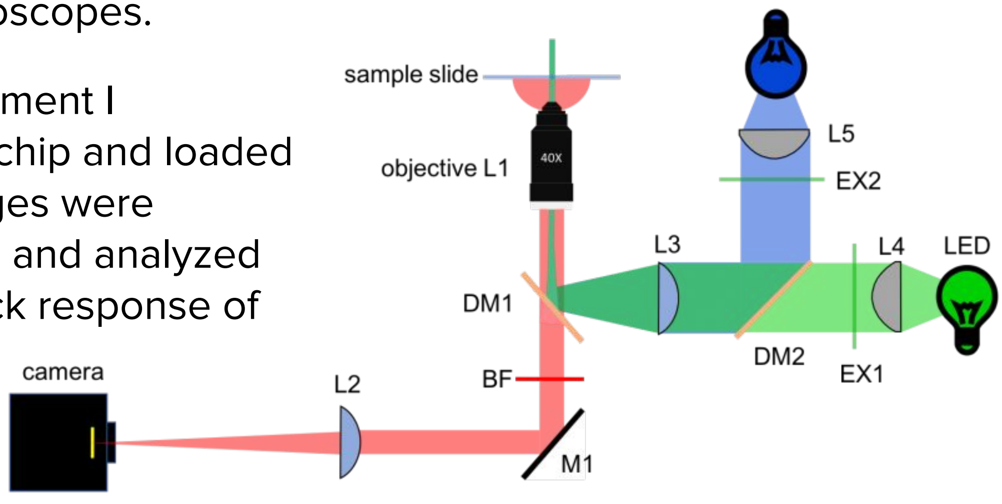
A sampling of my glassworking - unfortunately many projects have been given as gifts prior to being photographically recorded

Microscope & Microfluidic Chip

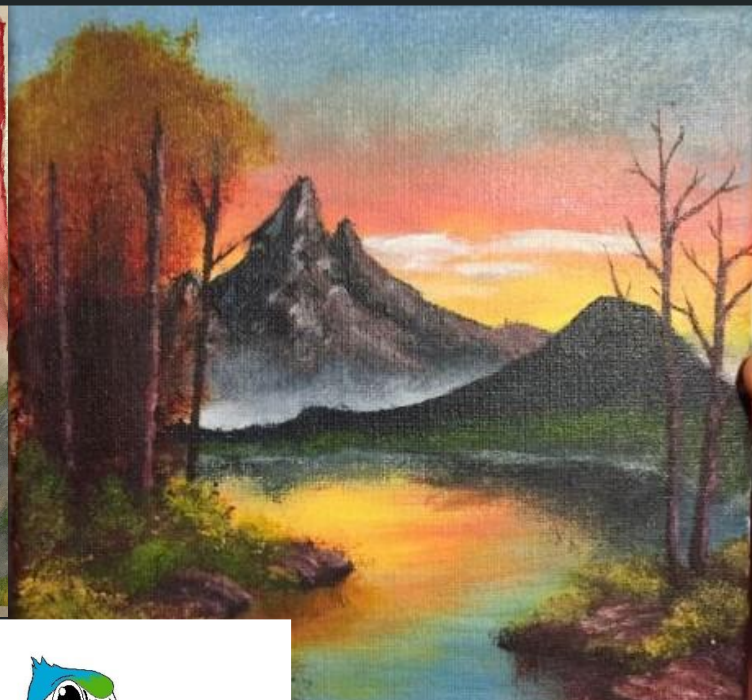


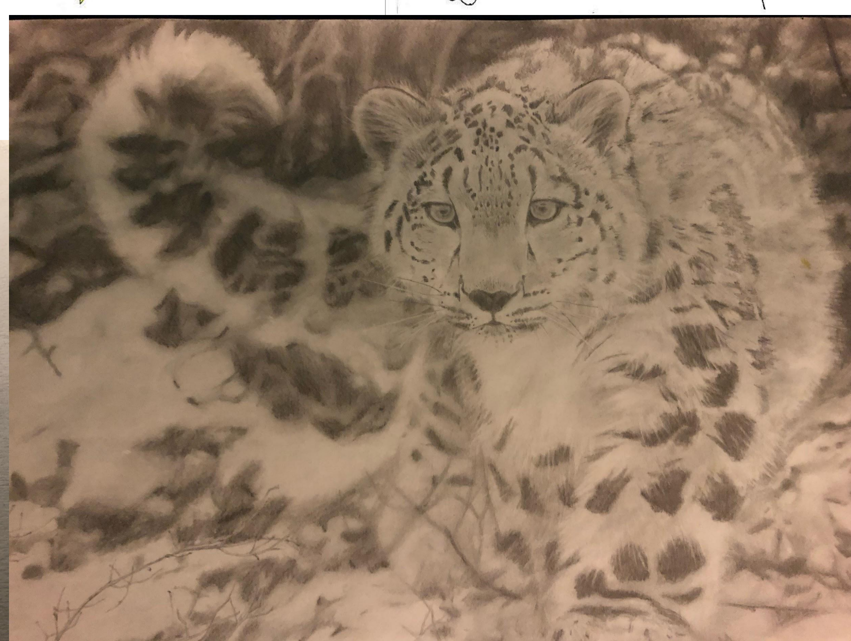
Biological Instrumentation and Measurement (20.309) has been one of my favorite courses at MIT. In it, I learned about optics and built a microscope capable of transillumination and epifluorescence. We then performed experiments with our microscopes.

For example, in one experiment I constructed a microfluidic chip and loaded it with live yeast cells. Images were programmatically captured and analyzed to assess the osmotic shock response of the yeast.



Other Art





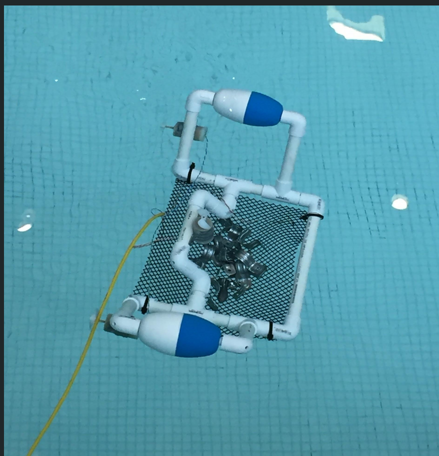
Top: acrylic, Middle: Adobe Illustrator, Bottom: watercolor (left), pencil (right)

TIM Candle

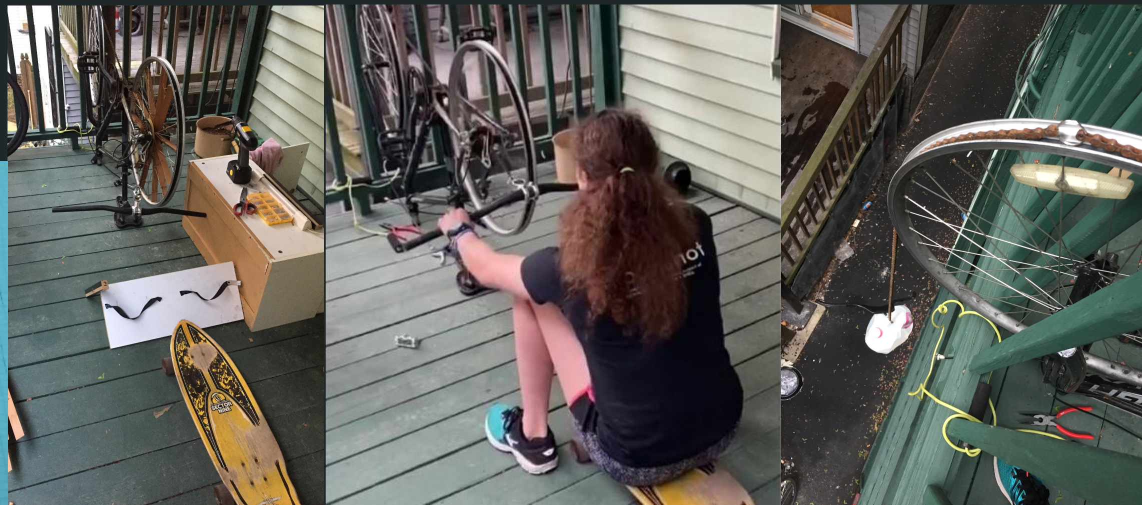
This candle was a fun project, highlighting the potential of a quick DIY casting process. The versatility of this process excites me; the possibilities are endless!

I first molded a figure (TIM the Beaver – MIT's mascot) out of clay and put him in a little bucket. Then I mixed and poured a silicone mold into the bucket and waited for it to set. Once it solidified, I carefully pulled the clay out of the mold and then used a needle to pull the thread through the top of TIM's head (bottom of the mold). I then poured in the wax to take the clay's place. Once dry, *voilà*! TIM was born.

ETC



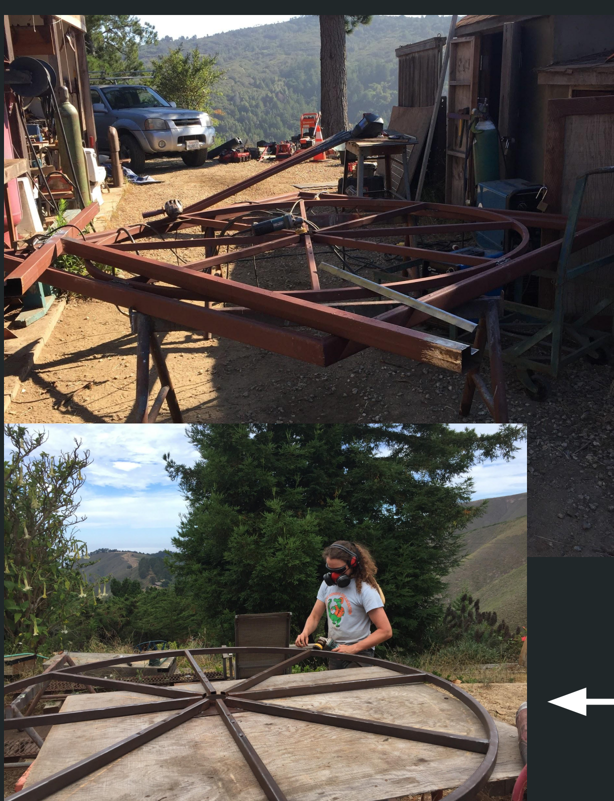
SEAPERCH (Underwater rover)



Makeshift Erg from old bikes

Laser engraved mirror for crew friend

brake caliper replacement, 3D printed water holder



Laser cut koi

CNC machining practice

Making a gate/learning to weld