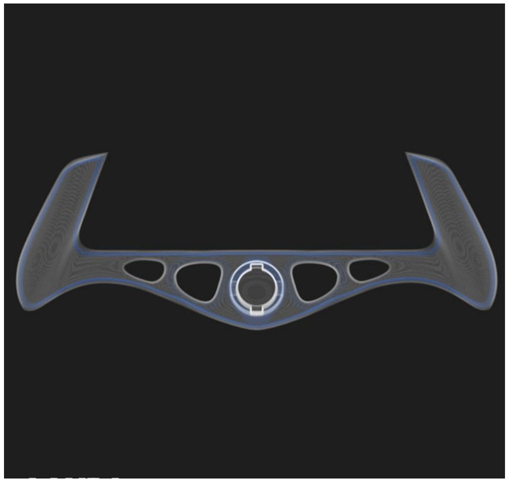
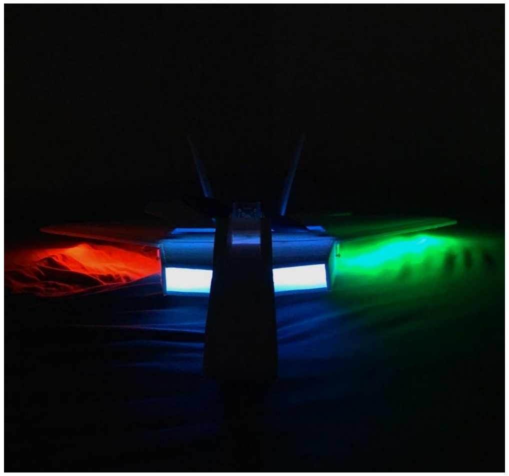
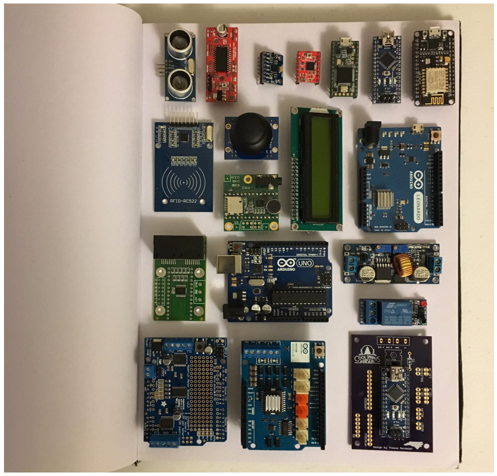
Tom Randolph

PROJECT PORTFOLIO

Handmade Innovations







ABOUT

Tom Randolph | thomas.randolph26@gmail.com | 413-822-1200

I am a senior mechanical engineering student at UMass Amherst.
I found my passion for designing and building things at a young age, so pursuing a career in mechanical engineering was a natural choice.
Within the past five years, I have pursued many projects involving skills in metalworking, electronics, programming, and mechanical design. These range from academic coursework, to personal undertakings, to entrepreneurial ventures. From each, I have learned in the most effective way possible — hands-on experience.

SKILLS

General:
Communication/Writing
Public Speaking
Networking/Outreach
Research

Technical:
Solidworks (Certified)
Creo Pro/E
ANSYS
Eagle EDA
C++
Python
MATLAB
Additive Manufacturing
Machining
Fabrication
Soldering
Embedded Systems

CONTENTS

Action Activated Lamp

Capstone Senior Design

For my capstone design project, I worked with a team of five senior engineering students on a robotic lamp. The purpose of the project was to create an autonomous, collaborative work light. The lamp can be used in exam rooms by physicians or medical staff to work on patients in a sterile environment. To make the operator's job simpler, the lamp will track hand movement and gestures to provide light wherever needed, without requiring the operator to touch the lamp.

I acted as the systems integration engineer for this project, working across all disciplines to design electro-mechanical systems to control the robot. This involved modeling assemblies in CAD, prototyping electronic circuits with motors and cameras, as well as writing code in Python and Arduino to model, simulate and control the robot.

Solidworks Rendering

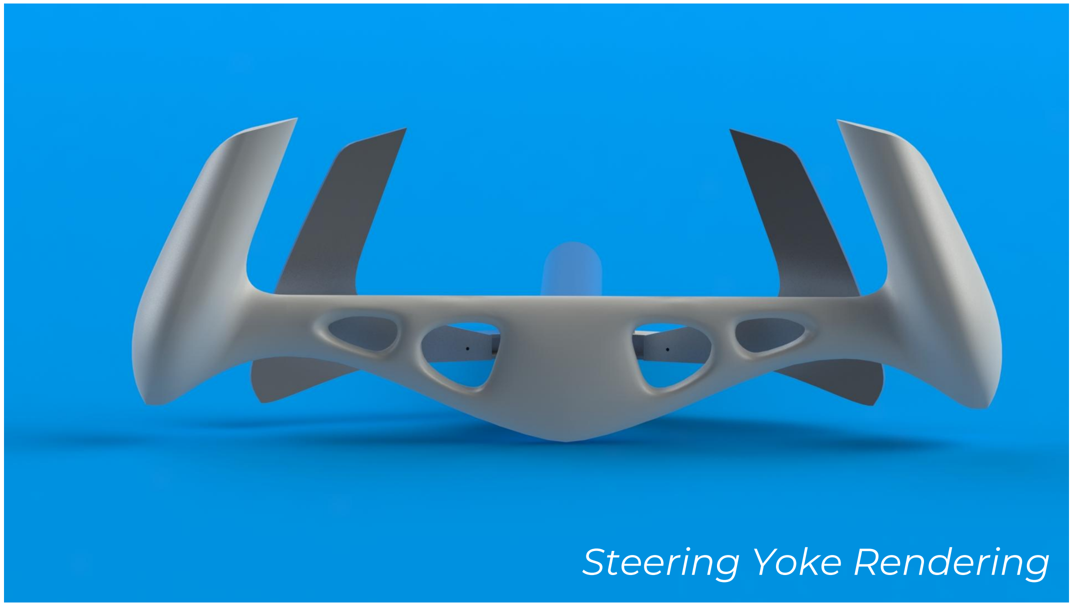
Python Control Algorithm

Super-mileage Vehicle

UMass SMV Team

Working with the UMass Super-mileage Vehicle Team, I designed a light-weight, modular, ergonomic steering yoke to replace the existing steering yoke. To reduce weight, the parts were printed in plastic with carbon-fiber reinforcement. Paddles are attached to the rear of the yoke and connected to the throttle and brake lines for the vehicle.

A second project I had for the team was to setup real-time telemetry and data-logging for the vehicle. For this, I outfitted the vehicle with a flight computer for drones, a GPS module, and a long-range telemetry radio. The radio communicates with a laptop base-station to relay information about the cars attitude, velocity, and position during the course of testing and racing. This allows for race-time decision making, as well as on-the-fly diagnostics and post-race performance analysis.



Steering Yoke Rendering

IoT Light

Internet of Things connected light sculpture

Light Installed

I built a mood light using live edge cherry lumber, LED strips, and a cloud-connected microcontroller. The cherry board was mounted to the wall with several LED strips glued to the back. The segments of LED strips are soldered together in parallel to mitigate dimming at the ends of the strips. These are soldered to a perf-board LED driver board of my design, and the "Particle Photon" ARM-based microcontroller. Red, green, and blue channels are individually controllable via power transistors. The microcontroller's built-in wifi chip connects to Particle's servers and awaits commands via their Javascript API.

A simple Apache server running on an Amazon Web Services EC2 instance hosts a basic webpage where the client can select a color from a pallet of colors. This then sends RGB values to the Particle cloud via their Javascript API, which is relayed to the microcontroller. This allows users anywhere in the world to change the color of the lights.

I have recently been working to host the service with a Node.js backend running Socket.io. This allows clients' displays to be updated instantly when someone else changes the color of the light. This poses quite a few more issues for security, and thus is not yet implemented.

Sculpture Lighting

Garden Metal Work, Pedro S. De Movellan

While working for a small metal shop for a summer, I pitched the idea of putting lighting on some of the trellises the shop sold. My boss liked the idea and was willing to try it on a custom job he was doing. He let me help take a role in design and fabrication of the welded aluminum trellis and gave me complete control over the lighting. We used professional grade waterproof LEDs and power supplies and routed them discreetly around the back of the trellis to give a gentle backlighting as seen in the top image.

Garden Trellis

A local kinetic sculptor came to me with the idea of implementing LED lighting in one of his bigger projects. After he made the sculpture, I showed him several digitally controlled lighting options he could use. Once he assembled and mounted all the lighting, I coded some different dynamic lighting schemes, and he chose one to use for his installation at his gallery in NYC.

"CODE" by Pedro S. De Movellan

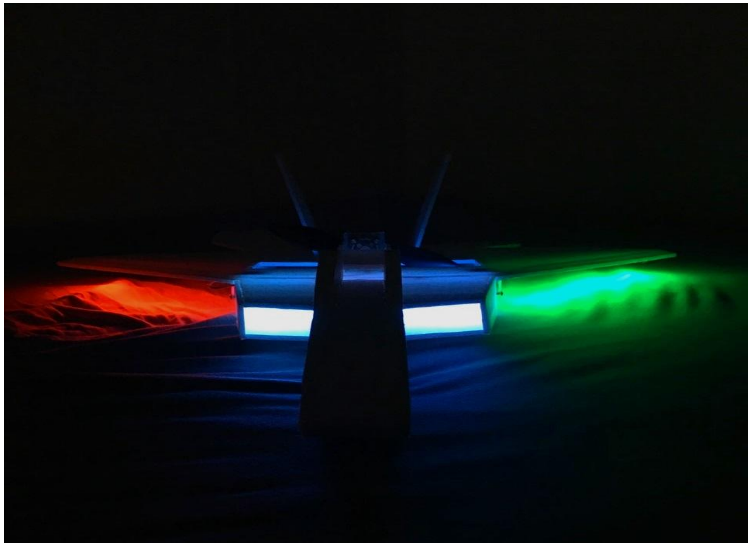
(video at: https://vimeo.com/190129009)

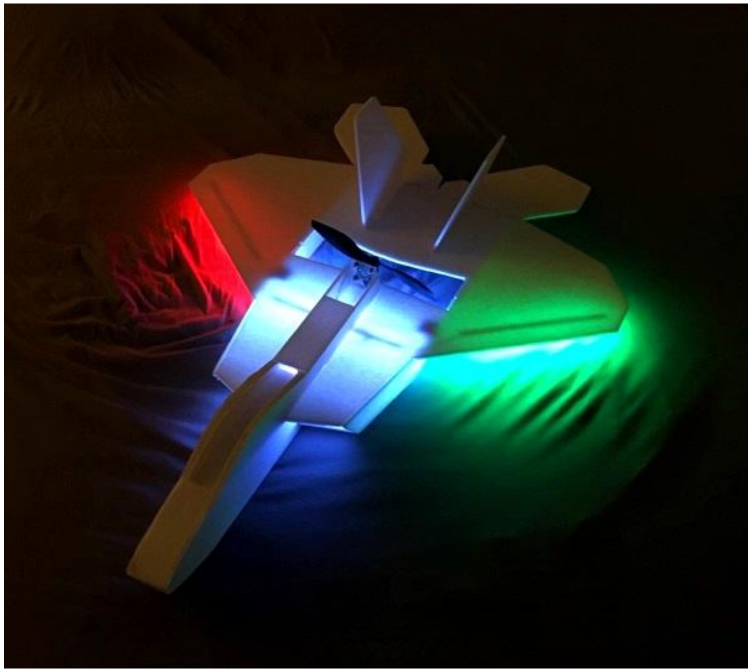
R/C Aircraft

Homemade Remote Controlled Planes

As far back as highschool, I have built R/C planes out of cheap and readily available hobby/craft supplies and learned to fly them. I studied the battery technologies, aerodynamics, communication protocols, flight characteristics, control theories, and budding technologies for various types of fixed wing and multirotor small scale craft.

Pictured is a design I cut out of foam board and assembled with glue. I fabricated a motor mount and soldered together and secured the motor, servos, leds, and control circuitry.





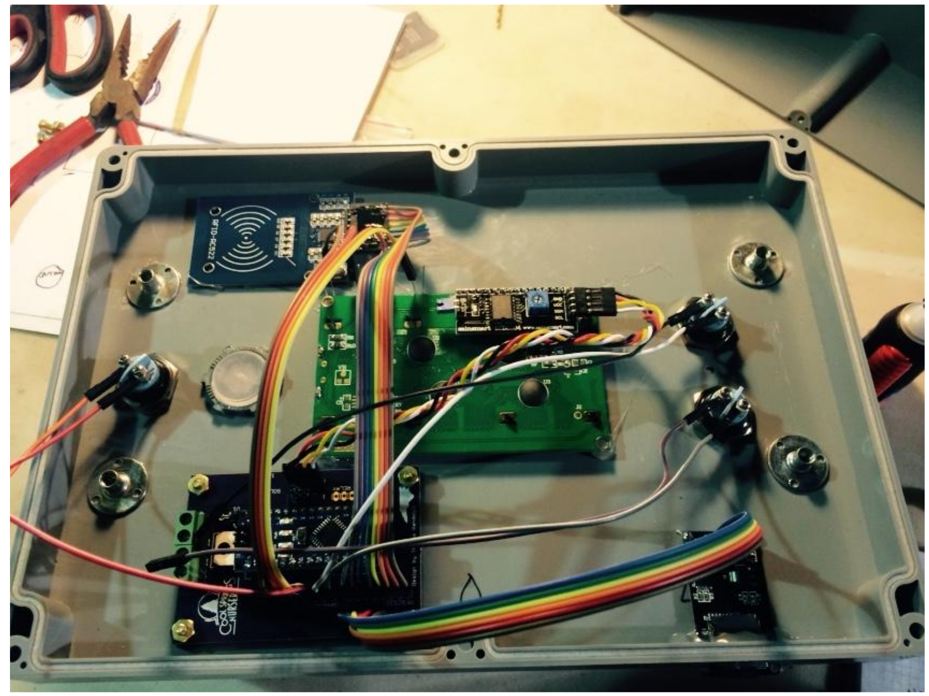
Industrial Garland Winder

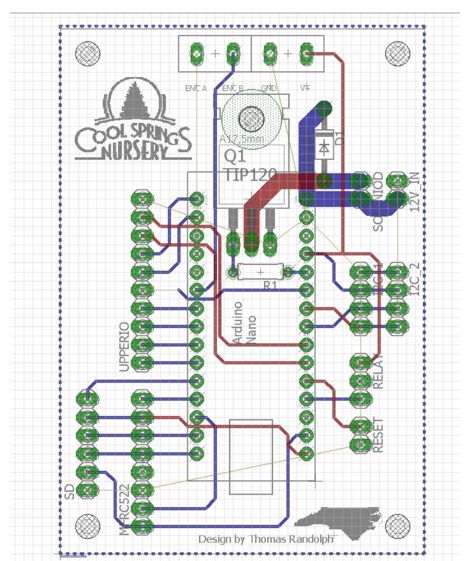
Cool Springs Nursery

For this project, I worked with a large-scale industrial Christmas tree farm to develop a better solution to track and log how many feet of garland workers were winding onto spools to send to customers.

The previous method involved pencil, paper, and mechanical rotary counters. Working closely with supervisors, I designed and prototyped a digital solution to log the feet wound per worker, and the type of garland being wound.

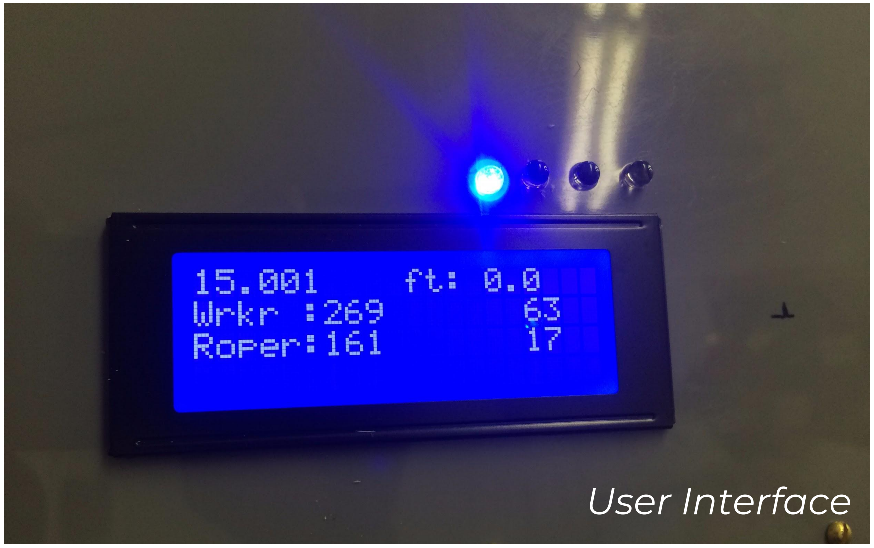
The solution offered the advantage of reliable, accurate, and traceable digital data that will increase time and cost savings for the farm by streamlining the logging system and reducing inaccuracies in the lengths of garland being shipped to the customers.



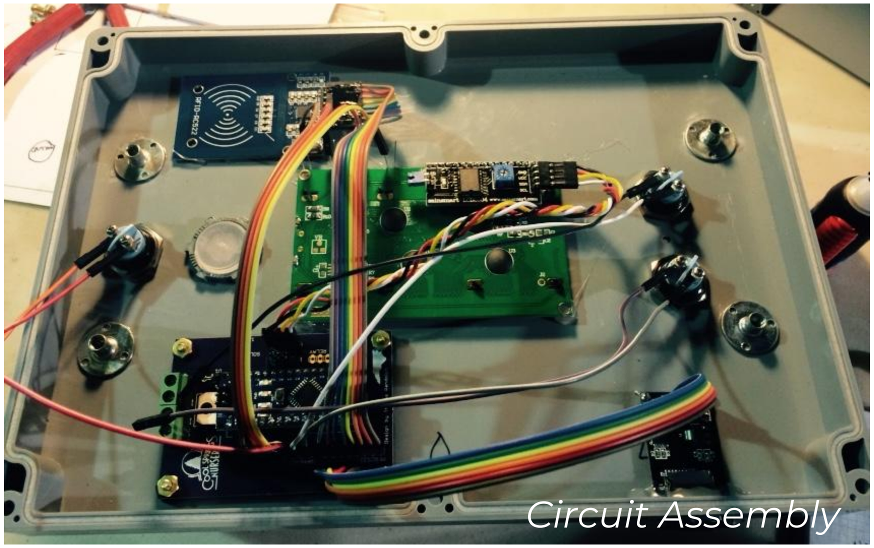


Industrial Garland Winder - Hardware

Cool Springs Nursery



User Interface


Circuit Assembly

I designed an intuitive User Interface with 20x4 LCD, three LEDs, RFID Card Reader, and three Pushbuttons.

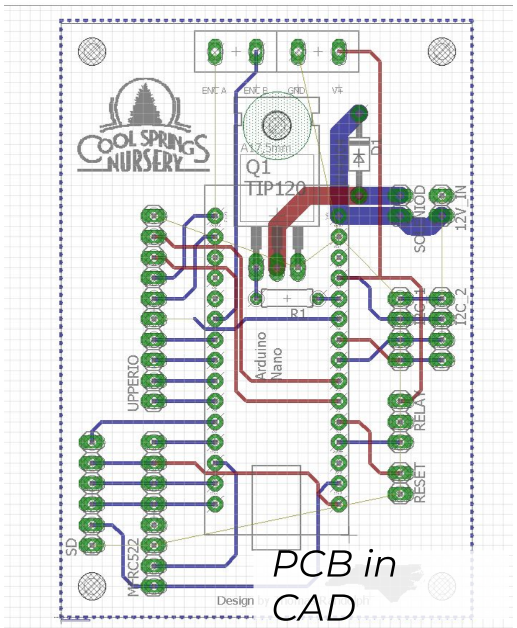
The data logged by the system can be extracted via a Micro-SD Card.

I prototyped and assembled complex circuits including the following components:

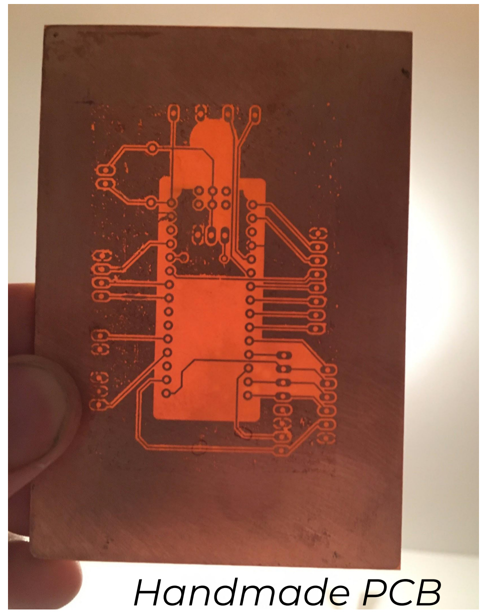
- LCD
- LED x3
- Custom PCB w/ ATMEGA328p
- RFID Reader
- Pushbuttons x3
- SD Card Reader
- Rotary Encoder

Industrial Garland Winder - Custom PCB

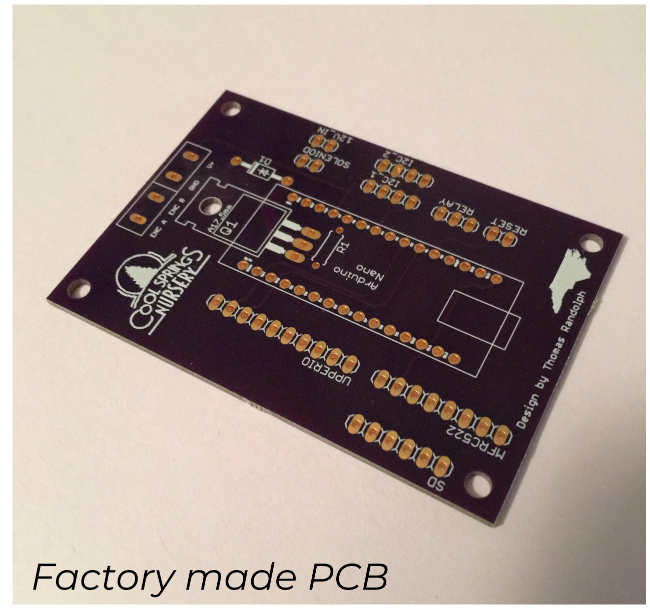
Cool Springs Nursery



PCB in CAD



Handmade PCB



Factory made PCB

After several iterations of testing on breadboards and perf-board, I drew up the final PCB in EagleCAD.
I designed it around the Arduino Nano Microcontroller, with breakout pins for the peripheral components, as well as options for a through-hole transistor, diode, and resistor to drive an optional actuation solenoid.

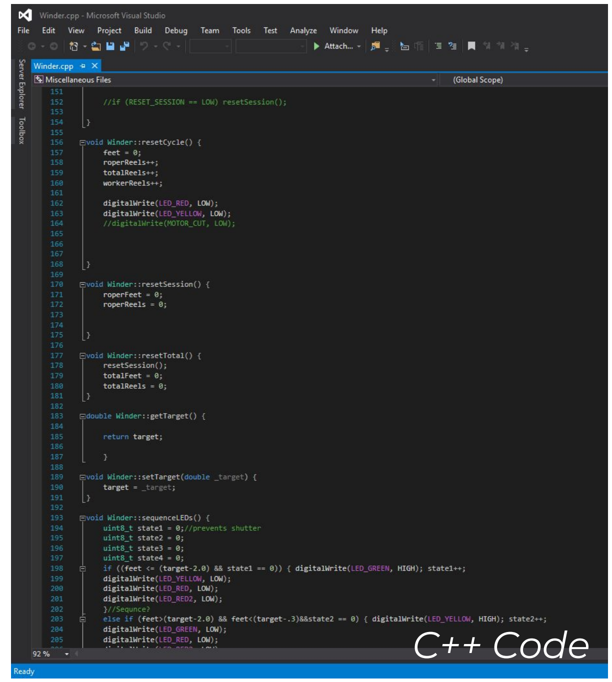
I then etched the PCB onto a bare-copper prototype PCB at home using the toner-transfer method.
This method involves using a laser printer, a laminator, an etchant solution, and some household chemicals to etch the traces from a piece of copper-clad composite board.

Finally, I had the PCB made professionally by OSH Park.
The final board was identical to the home-etched one, but with a solder mask applied to the surface and gold-plated pads.
I was also able to have them apply a silkscreen logo and text.

Industrial Garland Winder - Custom Software

Cool Springs Nursery

Arduino Code



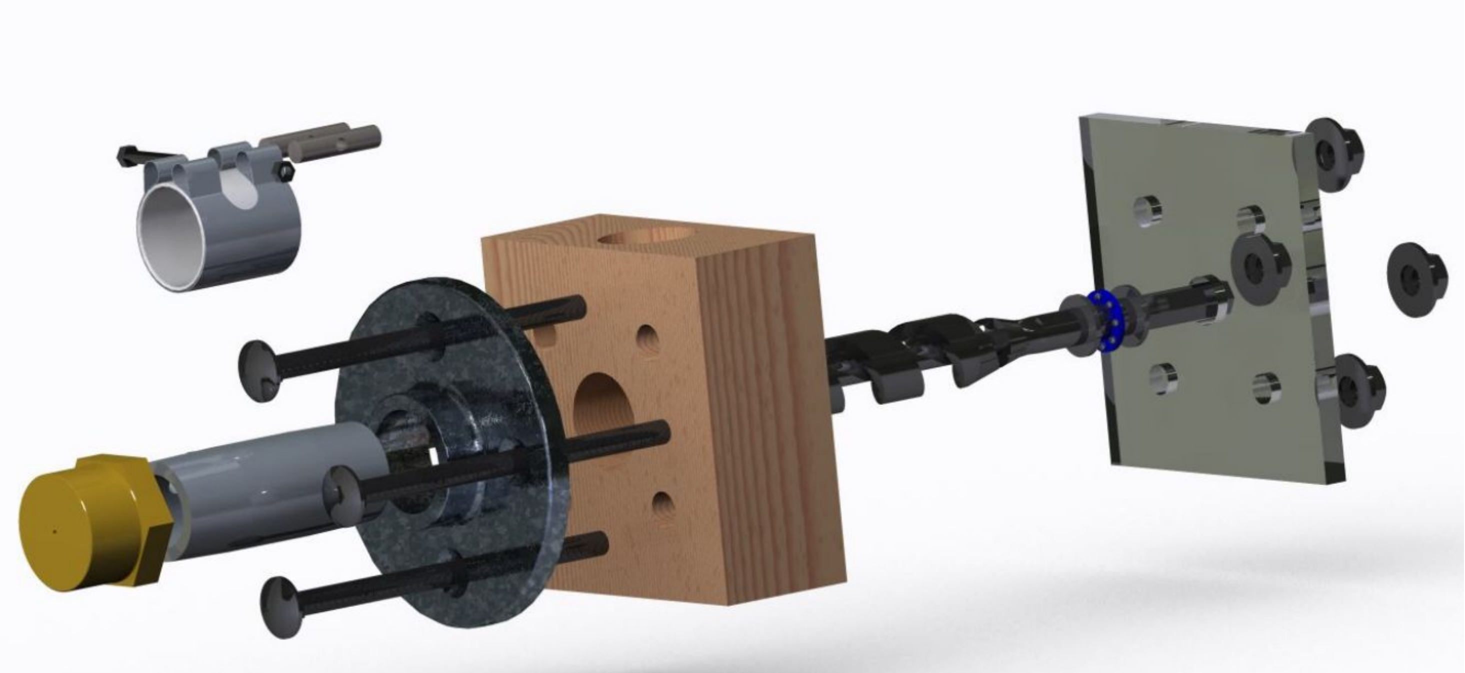
C++ Code

I developed many iterations of Arduino Code to write the data logging and user-interface software, adding more functionality and features each time. Initially the software only logged the distance of garland wound to an SD card, but eventually I added an interface for an RFID card system to track who was using the machine and details about the garland.

I wrote several completely custom libraries for the winder in C++ using MS Visual Studio. I also needed to reverse engineer the communication protocol used to link the RFID Reader to the Arduino ATMEGA chip. I was then able to modify and extend the functionality of the module's pre-existing library.

Filament Extruder

Freshman Design Project



Extruder Creo Model

For this project, my team and I were tasked to design a sustainable product. We chose to design an affordable, at-home solution for recycling ABS plastic into 3D printer filament. The design involved heating ground up pellets of plastic and extruding them through a die. The extrusion was to be done with an auger bit and a high-torque stepper motor, and the heating to be done with an electric heater regulated by an Arduino and thermocouple through a PID loop. All major components could be bought affordably and assembled with relative ease.

I designed the model in CAD, built a rough prototype, and presented it to my peers and professors.

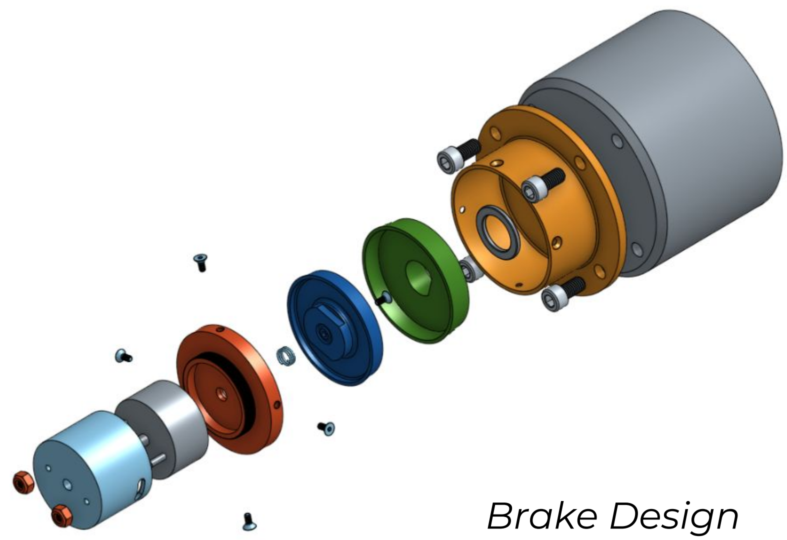
Mechanical Assemblies

Senior Design Class

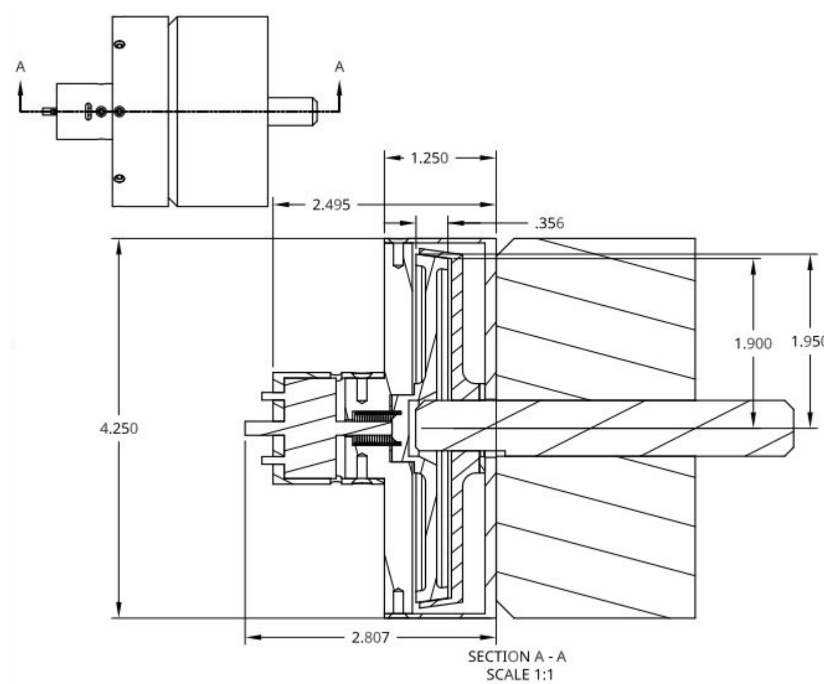
In our senior Design of Mechanical Assemblies class, we were given several small projects to complete within a week. Each project was set up to give us experience logically working our way through a design challenge to come up with an optimal solution given certain design freedoms and constraints.

Our first project was to design a gear train for an electric ice auger. We were given statistics of the motor and the loading it would experience, and had to choose from a vast catalogue of gears to create a gearset that would be small and have a reasonable fatigue lifetime. To do this I created an optimization algorithm in python that would find the most compact arrangement of gears that would not fail from fatigue.

Our second project involved designing a solenoid actuated brake to stop a specified motor in a short, specified amount of time in case of emergency. The first segment of the project was individual, and the second half was a group effort. For the group design, my teammates decided to put me in charge of the mechanical design after seeing how compact and well thought out my individual design was.



Brake Design



Manufacturing Fixture

Junior Design Project

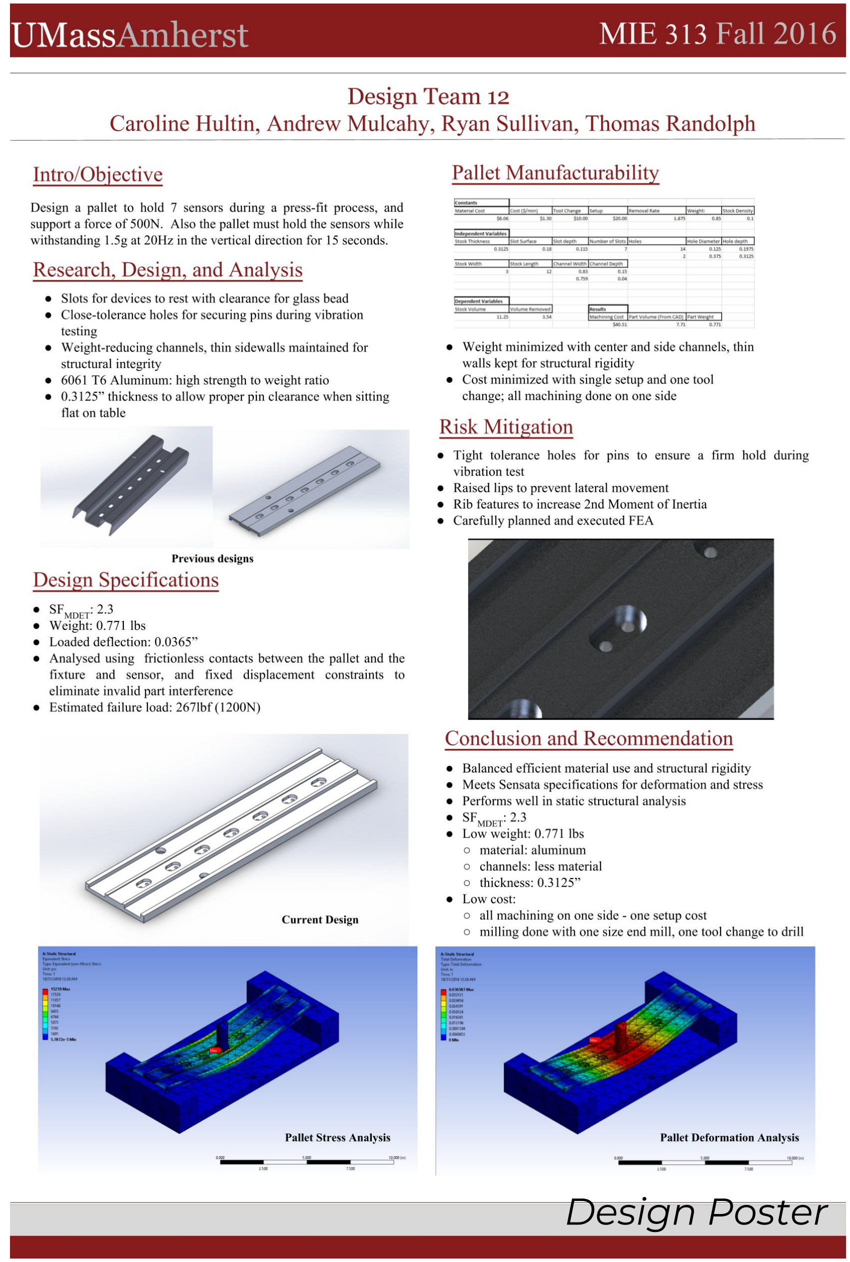
For this project, my team of classmates and I were assigned a semester-long project to design, analyze, and manufacture a fixture for use in an industrial assembly process. We were given design criteria from employees of Sensata Technologies.

The fixture was to hold 7 sensor devices to be press fit assembled on an assembly line. For that reason it had to withstand a load of 500N with minimal deflection, and had to be able to retain the devices securely under a vibrational test.

We used SolidWorks for 3D design work and ANSYS for FEA. We 3D printed a prototype to pass vibrational testing, and manually machined the final prototype to perform structural tests on an Instron. Throughout the process, we kept the Sensata employees and the professor up to date with our results via professional, in-depth memos.

Our final metrics including analysis accuracy, cost, and weight were graded on a scale against the other teams. Our design was the cheapest, passed the vibrationally test with ease, and was one of the lightest, scoring our group very high overall.

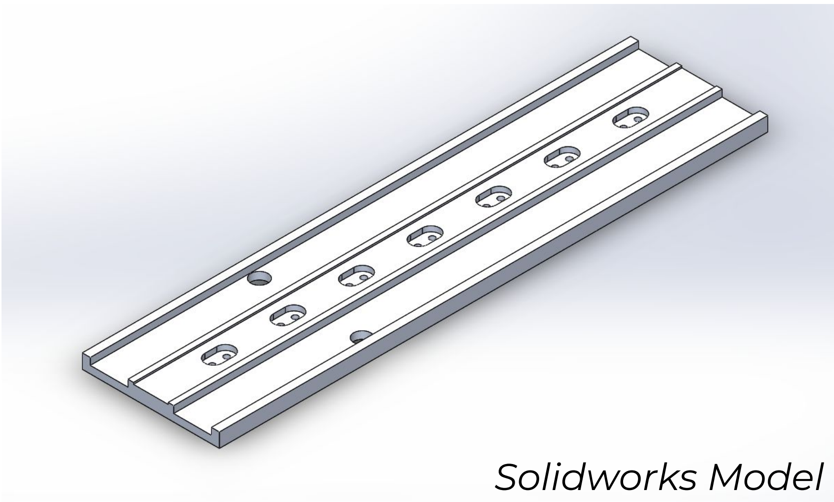
I was responsible for most of the mechanical design, and led the analysis and manufacturing effort.



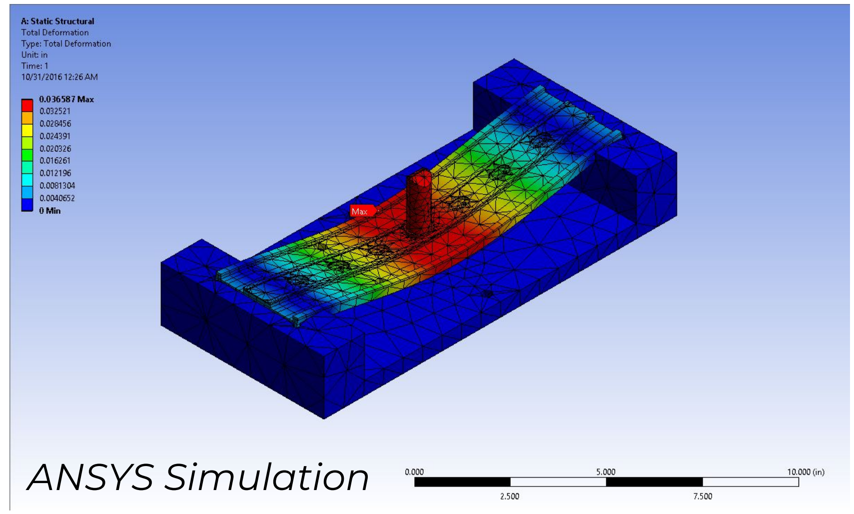
Design Poster

Manufacturing Fixture - Design and Analysis

Junior Design Project



Solidworks Model



ANSYS Simulation

With several mandatory major dimension and the stock size of the aluminum we were using in mind, I designed our pallet to be as simple as possible to save on machining cost. By trying various material thicknesses in ANSYS, I determined the thinnest safe material thickness, and made simple cuts that could quickly be made on a manual mill with a single end mill. By reducing machine setups, tool changes, volume of material removed, and cost of material, we were able to arrive at a price of around $40, which was half of the average cost for the class.

Once our design was finalized, we performed detailed static structural analysis in ANSYS to predict the deflections the fixture would see under testing. I took careful consideration to the boundary conditions of the model to ensure realism. We included a plasticity model for our material and recorded simulated deflection at various load timesteps. I used this data in a mathematical model in MathCad to predict the failure load, as defined by the assignment.

Manufacturing Fixture - Manufacturing & Testing

Junior Design Project

Vibration Test

Fixture after Structural Test

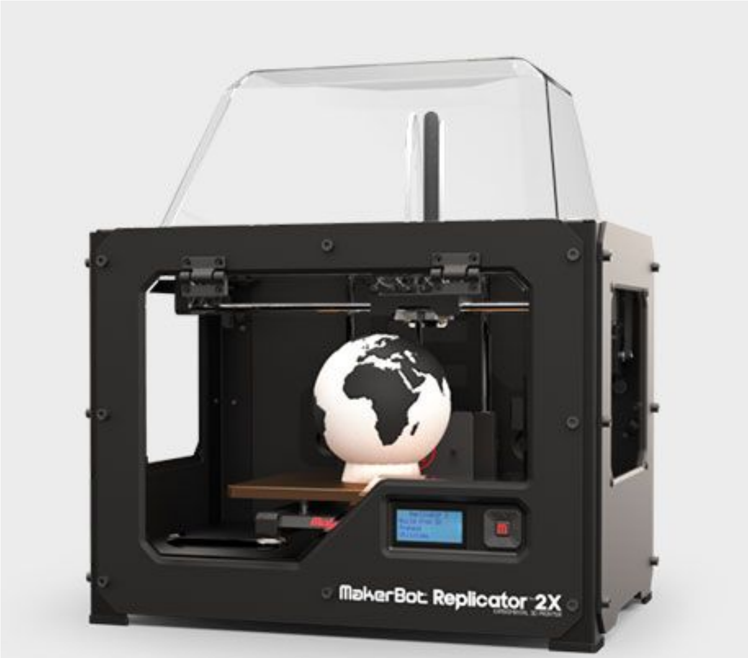
We had a 3D printed model made of half of our fixture, so it could easily be mounted to the lab's small shaker (see above). The devices to be assembled were inserted and the test was conducted at 1G vertical acceleration and 20 Hz frequency. Carefully placed holes constrained the devices laterally, preventing them from tipping as it shook, resulting in virtually no movement of the devices throughout the 20 second test. (https://www.youtube.com/watch?v=A9DEINfZrjM)

After passing vibe, we machined the fixture out of 6061 T6 Aluminum on a Bridgeport vertical mill. We confirmed that our dimensions were in spec. and tested it by loading it vertically on the centermost device mounting position. The fixture handled regular loading condition (500N) with no permanent deformation, and did not meet failing criteria until around 3000N, passing all design criteria with a large margin of safety (notice slight permanent deformation in image).

MMRHS Makerspace

Monument Mountain Regional High School

In my final semester at Monument Mountain Regional High School, I came up with the idea of a student makerspace with my physics teacher/mentor. We worked with the administration and the library to arrange a physical space. I wrote a budget proposal complete with hundreds of supplies/equipment to stock the space. Finally, I met with the board of School Center Inc. to discuss the necessity of the makerspace and go over my budget proposal. After listening to my pitch, and asking me questions about my take on STEM education and its place at MMRHS, the board gladly accepted the proposal and granted the school $4000. I oversaw the purchasing of the equipment with the majority of the budget going to a new 3D printer.



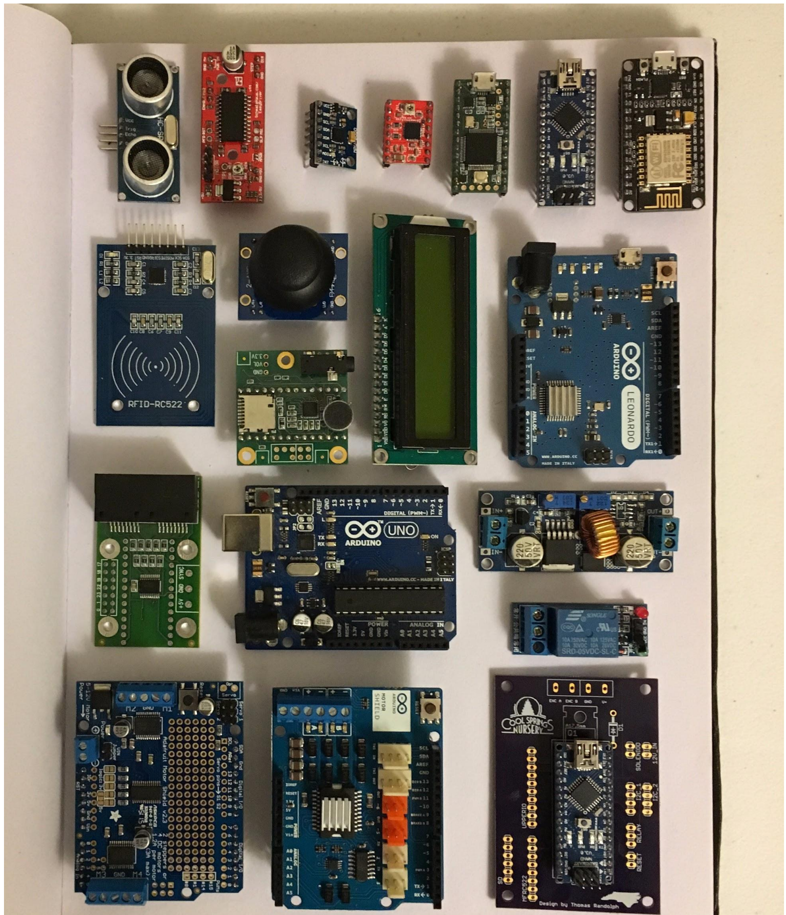
3D Printer (www.makerbot.com)

Presently, the makerspace has seen use for by plenty of inspired students to work on projects that they could otherwise not do in school.

Microcontrollers

Aside from my larger projects, I have taken on countless smaller hobbies and projects, mostly involving electronics. I have accumulated hundreds of dollars of electronics over the years, an investment I have made to further my understanding of embedded systems and robotics. I have dabbled in control systems, actuators, motors, sensors, digital signal processing, led lighting, remote controllers, the internet of things, and more.

Pictured is part of my collection of microcontrollers and single-board computers including 8-bit AVRs, to 32-bit ARMs and peripherals such as motor drivers, LED strip controllers, LCDs, Audio processing modules, sensors and WiFi chips.



Microcontroller Collection