Christopher Rhoades
Engineering Portfolio
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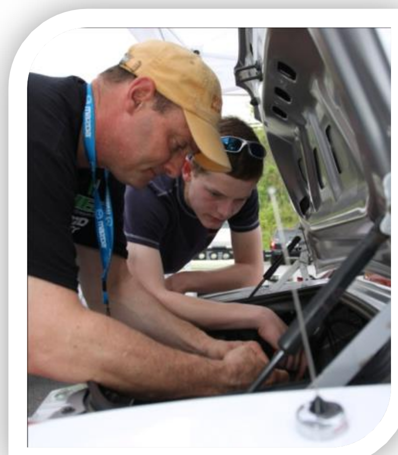
## Introduction

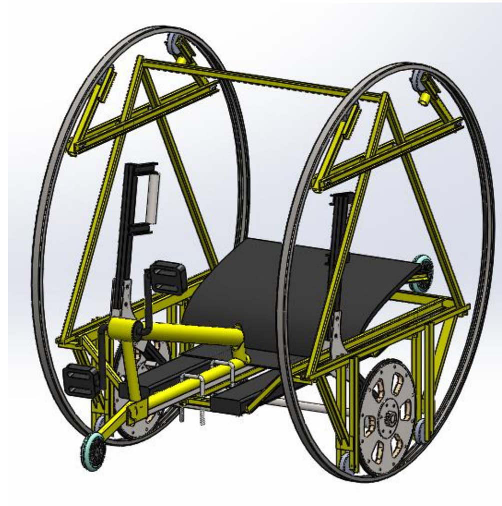
Hello. My name is Christopher Rhoades, and I am an Engineering student at the Thayer School of Engineering, Dartmouth College. This portfolio is designed to supplement my resume by demonstrating my Engineering project experience. One of the greatest qualities of the program at Thayer, in my opinion, is the emphasis on hands-on projects. We don't just complete problem sets and make predictions of how an assembly will work; we go to the machine shop to create parts with our own hands, make the assembly, and then test how the device *actually* works. Thank you for taking a look at what I have created.

## About Me



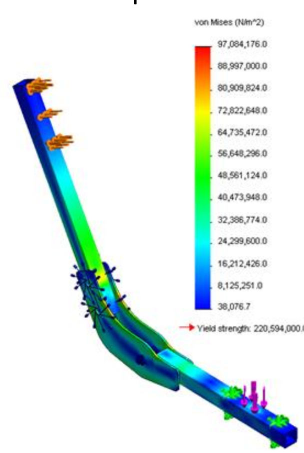
Since I was a kid, I have been fascinated by all things mechanical. I took apart old printers to see how they worked, created entire cities with Lego blocks, and never missed an opportunity to sit in my Dad's lap to drive boats, cars, or other vehicles. My curiosity of how things work—specifically vehicles—has remained, and now I spend much of my free time designing Dartmouth's Formula race car, wrenching on my 1978 Toyota FJ40, and watching videos of new car technology and sports car races. I have competed in SCCA (Sports Car Club of America) club regional and national races, the SCCA Pro Racing Playboy Mazda MX-5 Cup Championship, and the NASA (National Auto Sport Association) 25 Hours of Thunderhill endurance race. Ultimately, I hope to make a career as an Engineer in the automotive industry.

## *Diwheel*



For *ENGS 146: Computer Aided Mechanical Design*, our team of four students created a human-powered diwheel, a machine that uses two large hoop wheels sharing a common axis of rotation to move. Over the course of roughly three weeks, we were required to design, fabricate, and race this machine against seven other teams. Because of this short timeline, we did not have the opportunity to make prototype designs. Instead, we relied heavily on a robust CAD model, computer simulations, and engineering calculations to ensure our machine would be operational on race day. Additionally, we incorporated adjustable mechanisms into many parts of our design to allow for fine-tuning as necessary.

All teams were provided a finite amount of steel square and C-channel stock, (2) 42" diameter hoop wheels, and (2) abandoned bicycles for parts cannibalization. Additional supplies such as bearings, springs, and wood were either ordered from McMaster-Carr or scavenged from old projects around Thayer School. After researching previous diwheel designs, we designed our own in SolidWorks. Our design utilizes a single, shared driveshaft for the two hoop wheels, which are driven by smaller drive wheels that ride inside the hoops. To steer, the rider pushes on the left and right spring-loaded levers, disengaging the drive wheel on a particular hoop and allowing for "skid steering."

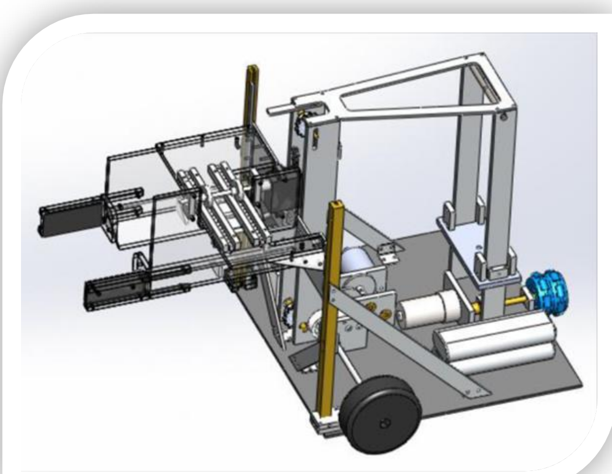


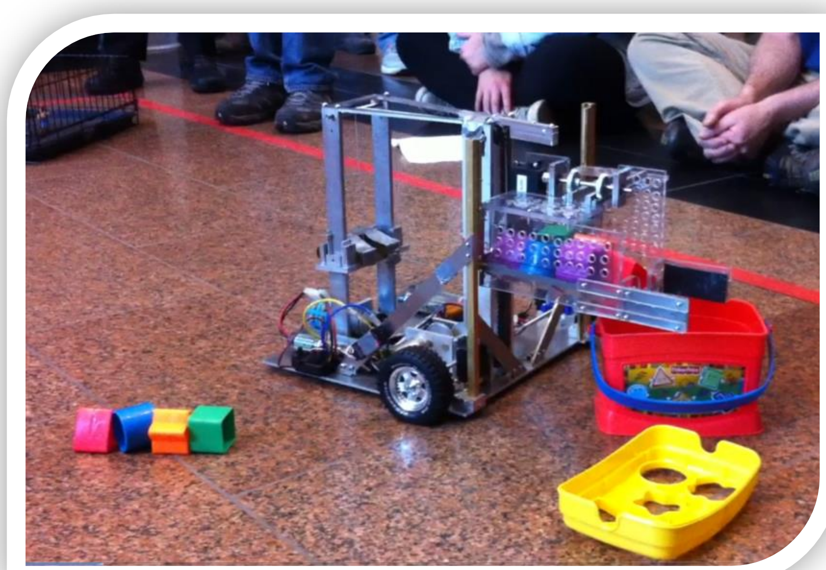

We created numerous iterations to ensure the machine's center of mass (with rider) was acceptably low and directly below the axis of the hoop wheels. Once we were satisfied with the general framework of the design, we performed FEA studies and subsequent design iterations on specific components to ensure structural strength. We MIG welded the frame in two days and then moved forward with the rest of the assembly. In the end, we created a working machine for the competition and finished in second place out of eight teams.

## *RC Robot*

For *ENGS 76: Machine Engineering*, my three teammates and I designed and fabricated a radio-controlled robot for a competition among 10 groups. The objective of the competition was to score as many points as possible in a fixed amount of time by playing four children's games, each of which had a unique point structure based on completing specific portions of the game. One game was to open a latched pet cage and remove a small action figure from the cage ("Rescue Woody"). Another was to construct a Lincoln Log cabin. Another was to pick up plastic rings and stack them in order on a peg. The last game was to pick up solid blocks of various shapes and place them in a bin (see picture below right). We were provided with a finite kit of materials, including aluminum, brass, polycarbonate, and acrylic plates, aluminum gears of various sizes, ball bearings, and shafts. In order to get a better sense of our machine's challenge, we tried the games by hand to provide insights for our design process. Given our material constraints, the point structure, our testing with the games, and our estimates about fabrication complexity, we decided to focus our effort on 3 games: all except Rescue Woody.

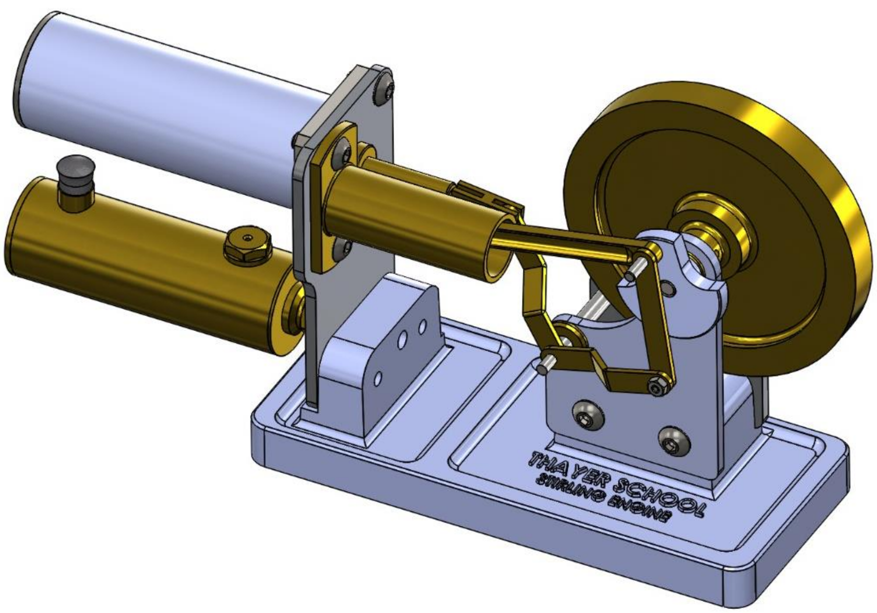
We designed the entire robot assembly in SolidWorks (see screenshot below left), which had more than 70 individual parts. During the design process, we kept track of material usage to ensure we could make each part with the materials available to us, and material constraints occasionally required us to redesign parts. We machined the parts using Prototrack upright mills, CNC lathes, and a Laser cutter. Apart from a differential and wheel assemblies from a Ford F-150 RC truck kit, all of the parts were made by our team, by hand. We spent countless hours machining parts, and then countless additional hours testing and refining subassemblies of our robot when the first attempt didn't work. In the end, we won two out of the three rounds of the competition. More importantly, I came away with the satisfaction of putting my heart and soul into this project and seeing it from a competition objective to a working machine. I gained invaluable experience working in a small group, in which there was no designated leader, to complete a complex project in a short amount of time with limited resources.





## *Stirling Engine*

I created this Stirling Engine as part of a course I took, *ENGS 25: Thermodynamics*. Using CNC upright mills, lathes, brazing torches, and other fabrication tools, I machined components for the engine from raw aluminum and brass stock. After assembling the engine, I tested its performance against that of my peers' engines. My engine produced the highest power output of all 19 student engines made in the class, more than 8% higher than the second-most powerful engine. It was also the most efficient engine in the class in terms of fuel burn rate to power output by more than 5%.

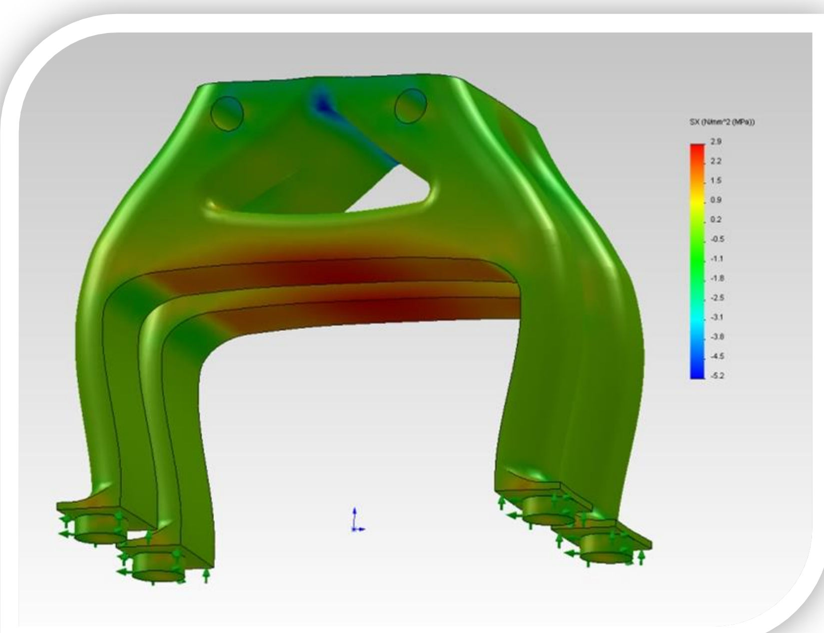



## *Tower Structure*

For this project in *ENGS 33: Solid Mechanics*, my two teammates and I created a scale model structure of a double-decker highway support. We were required to build the structure within a spacial constraint of 8”x4”x6.5” and a volumetric constraint of 55 cubic inches. Furthermore, we had to design a 3.5”x5” clearance profile through the entire structure to simulate the space through which traffic on the first level road would travel. After creating a Solidworks model of the structure, we rapid prototyped the final design (shown below) using a ZCorp Z650 3D printer and tested the accuracy of our predictions. The objective of this project was to make the double-decker highway support and:

- maximize failure load to structure volume ratio
- minimize vertical displacement in compression
- accurately predict failure load, location, and mechanism
- accurately predict vertical displacement at 500 lb applied load

To make these predictions, we designed a structure meeting the required specifications in Solidworks and iteratively refined it using finite element analysis. In order to create an accurate CAD model of the final product, we tested small samples of material printed by the ZCorp printer in an Instron electromechanical load frame and then calculated their material properties. We used those material properties in our FEA to simulate the way in which the final rapid-prototyped product should behave under load.



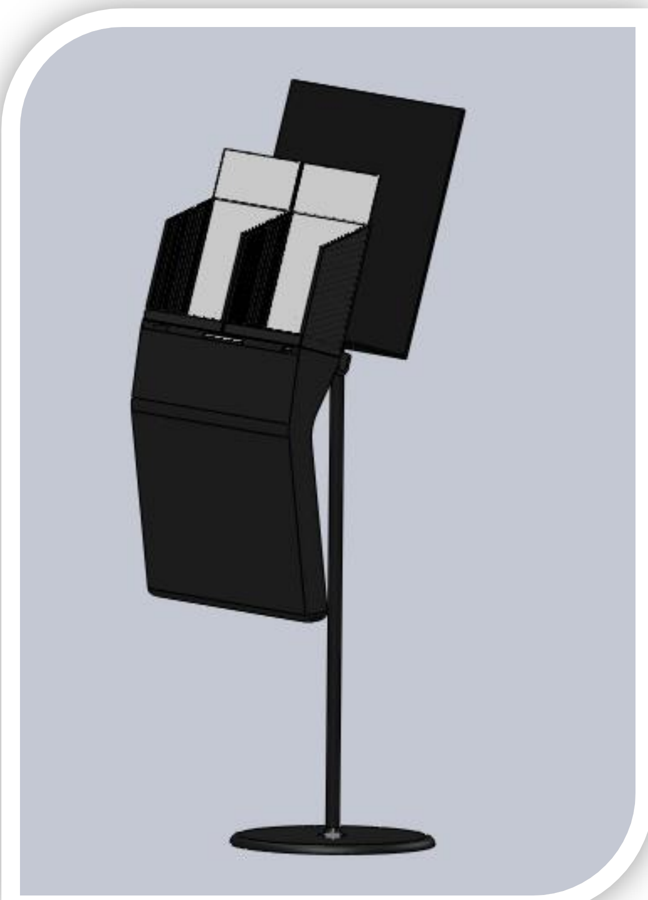

At the end of the course, we tested the final product in a competition against structures made by the nine other groups in the class. Our structure withstood the second-highest applied load of any structure in the class (1528.05 lb), which was 243.05 lb higher than our conservative failure load estimate. We made the third-closest failure load prediction, fourth-closest deflection prediction, and we created the second-most efficient structure in terms of failure load vs. volume of material used.

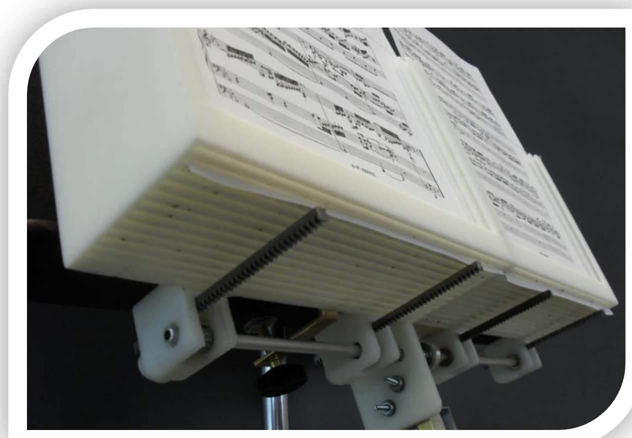
## *Spray Paint Rack*

While working at Local Motors in the winter of 2011, one of my jobs was to spray paint small steel components before they were affixed to the car. In order to make this process easier, I decided to fabricate a rolling rack from which to hang parts while I painted them and let them dry. To optimize the number of parts I could simultaneously paint without over-spraying, I created three staggered levels of three hanging poles each. This project means a lot to me because it was entirely self-motivated. I wanted to make my spray painting job easier and more efficient, so I asked if I could take a few hours to design and construct a device to fit my need, and I made it. Not only did I end up with a device that did what I wanted it to do, in the process of creating it I had the opportunity to design something from scratch, devise a plan for fabricating it, and practice welding.

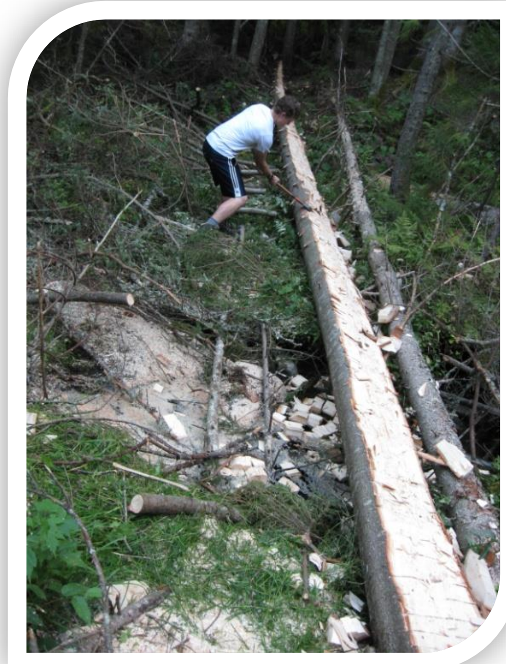
## *Page Dropper*

This project was the focus of *ENGS 21: Introduction to Engineering*. In this class, students were given the broad prompt of designing and creating a device to solve an everyday problem. My four teammates and I identified the problem that turning sheet music disrupts a string musician's ability to play continuously during a performance. Keeping in close contact with Dartmouth performing musicians, we created a set of specifications pertinent to the particular problem we aimed to solve. We implemented multiple decision matrices to decide on a final design: a foot-pedal-operated, solenoid-actuated "page dropper." This device (pictured below) consists of slots for pages of sheet music, similar in construction to an accordion binder, with horizontal retracting arms supporting the pages. When the user actuates the solenoid via the foot pedal, the arms retract a finite distance to allow two side-by-side sheets of music to fall into a receptacle, revealing the two pages behind them.



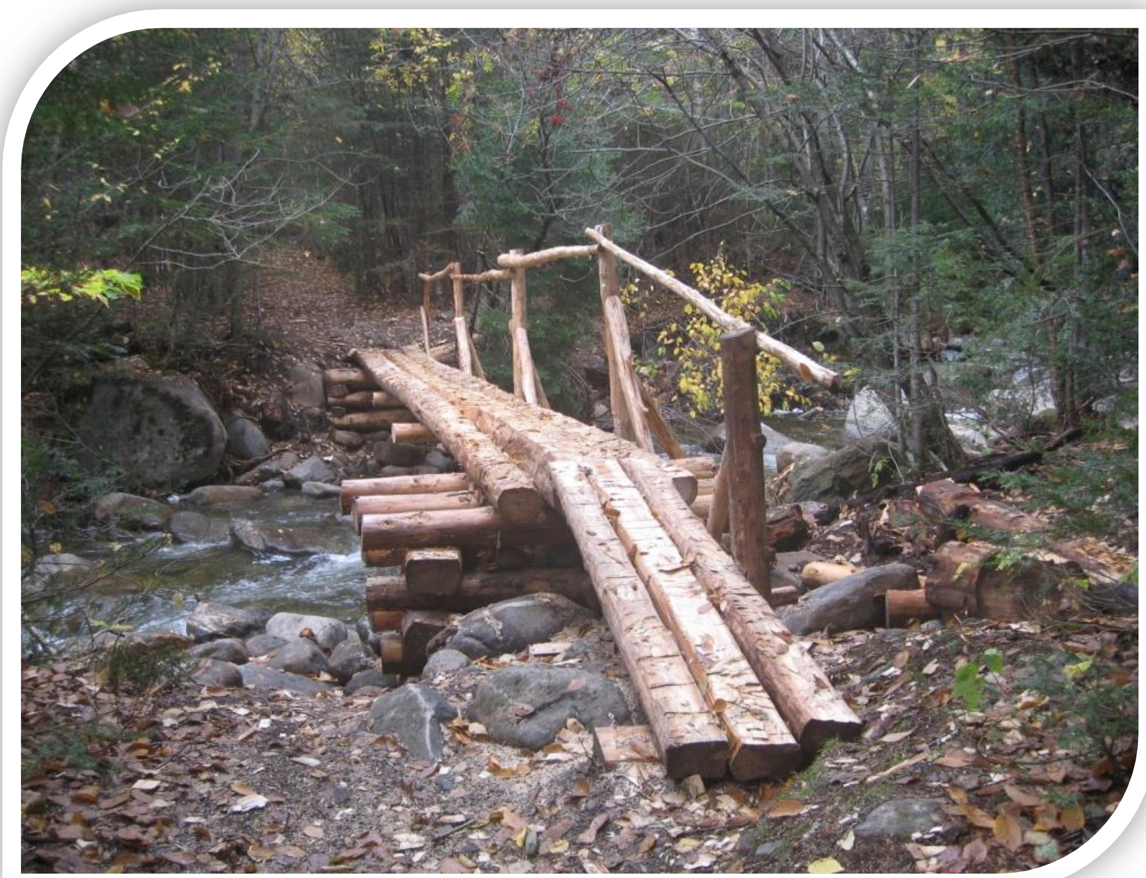


## *Ridge Trail Bridge*



In August 2011, Hurricane Irene washed away a hiking bridge spanning the Baker River on Mt. Moosilauke in Warren, NH. As a leader in Cabin and Trail, a sub-club of the DOC (Dartmouth Outing Club), I regularly work on trails that Dartmouth maintains on the Appalachian Trail and Mt. Moosilauke. Because of my trailwork experience, I was hired to design and construct the replacement bridge with two recent Dartmouth alums. Due to the extensive soil erosion created by the floods on the river banks, the new bridge needed to span nearly forty feet. Using pine trees that fell during the storm, we created a longer and more robust bridge to span the river. Our team of three people:

- de-barked the trees
- topped the logs to make flat walking surfaces
- constructed log cribs on either end of the river to support the span logs
- hauled the span logs into position with a chainsaw winch
- assembled the bridge



# Christopher Rhoades

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## Education

**Dartmouth College, Thayer School of Engineering** – Hanover, NH

- Bachelor of Engineering with Mechanical Machine Design concentration — March 2014
- Bachelor of Arts in Engineering Sciences (major), Japanese (minor) — June 2013
- Won Class of 1866 Prize for Oratory
    - Awarded to one member of the Sophomore class in a speech contest judged by a panel
- Studied at Kanda University of International Studies and lived with a host family in Chiba, Japan from June-August 2010
- Relevant coursework: Product Design & Prototyping, Scientific Computing, Solid Mechanics, Thermodynamics, Lumped Systems, Distributed Systems & Fields, Digital Electronics, Machine Engineering, Energy Conversion, Energy Utilization, Fluid Dynamics, CAD/CAM, Materials Science, Control Theory, Numerical Methods in Computation

**Saint Mark's School of Texas** – Dallas, TX — May 2009

- *Cum Laude*
- Community Service Board Co-Chairman
    - Oversaw school's community service program and volunteered over 550 hours of service
- Traveled on a photography expedition to Bhutan and Thailand
    - Contributed photographs to school's portfolio of student work in Association of Texas Photography Instructors statewide competition (ranked 1st in the state 2007-2009)

## Work Experience

**BRD Motorcycles** – *Mechanical Engineering Intern* – San Francisco, CA — Summer 2013

- Advanced FEA and design iteration for complex structural assemblies on *Redshift* electric motorcycle
- Nonlinear material research and FEA for motorcycle's thermoplastic rear sub frame assembly
- Design for manufacturing (injection molding, casting, forging, GD&T, mechanical drawings, BOM)

**Renovo Motors** – *Mechanical Engineering Intern* – Campbell, CA — Summer 2012

- Designed and prototyped 3 proprietary mechanical systems for high-performance electric vehicles
- Created Use Case, Assembly Instructions, and BOM documents
- Communicated with suppliers and contractors to ensure timely completion of system components

**Local Motors** – *Engineering Intern* – Chandler, AZ — Winter 2011

- Operated a MAXIEM Waterjet to machine car chassis and non-chassis components
- Prepared various sub-assembly components such as wiper motors, fuel lines, brake lines, amplifiers
- Designed and implemented heat shielding system for *Rally Fighter* vehicle
- Assembled cars: install drivetrain and suspension, trim and fit bodywork, wire stereo system

## Skills and Languages

- CSWP (Certified SolidWorks Professional)
- SolidCAM, MATLAB and C programming, Adobe Photoshop, MS Office Products
- CNC and manual mills, lathes, band saws, waterjets, plasma cutters, basic MIG welding, brazing
- Conversational in Japanese

## Leadership and Activities

- Dartmouth Formula Racing Team (Formula Hybrid and Formula SAE Electric competitions)
    - Source battery cells and design 5.4 kWh pack for safety, thermal management, low mass
    - Design and fabricate test rig for Mission Motors 85kW PMAC motor and MC600 Controller
- Compete in SCCA (Sports Car Club of America) and NASA (National Auto Sport Association) sprint and endurance races in Spec Miata class and the Mazda MX-5 Cup Championship
- Dartmouth Woodsmen's Team captain, Cabin and Trail club leader, Alpha Chi Alpha Programming Chair