U.S. Department of Energy (DOE) Collegiate Wind Competition

University of Massachusetts Lowell

GoJuice

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Executive Summary

GoJuice targets a new, highly profitable industry opportunity that links wind energy to portable electronic device charging. The company offers a network of free, ad-for-service, green energy mobile phone charging kiosks distributed throughout high-traffic urban areas. The purchase of a slim protective phone case with an integrated but swappable auxiliary battery admits the customer to the GoJuice kiosk network. The customer experience is streamlined: the old battery is removed from the GoJuice case, a 30-45 second advertisement is served on the kiosk display and a fully charged battery is dispensed. Once in the case, the new battery charges the mobile phone to significantly extend device usage. Revenues are derived from both the kiosk advertisements and device case sales. Both Android and iOS apps are included to further enhance the user experience.

Environmental responsibility and sustainability are the cornerstones of the GoJuice business. The battery swapping kiosks source the majority of their energy from renewable sources of energy such as wind and solar. By providing customers a practical, efficient and high quality alternative energy experience, GoJuice demonstrates that renewable energy can be efficient, effective and trendy.

The GoJuice team at the University of Massachusetts Lowell comprises an inter-disciplinary team of approximately twenty senior-level engineering students and seven faculty advisors.

Business Overview

GoJuice's mission is to provide a *worry-free, wait-free* solution to mobile smartphone charging. GoJuice supports consumers with an on-the-go and around the clock modern life through a unique and interactive one-minute phone charging experience. An auxiliary battery is used to transfer energy from the GoJuice charging kiosk to the user's phone via a custom-designed battery-holding case. By adopting the efficient, stylistic and renewables-based GoJuice charging system, users will save time, alleviate their battery range anxiety and reduce their environmental footprint.

Mobile phone cases containing a removable battery compatible with the market's major smartphone models will be sold and serviced. Consumers will enjoy their personalized, stylish case, which functions both as a fashion statement supporting renewables and as an energy reserve. In the transition between work and social activities, the user will make a quick stop at one of GoJuice's many kiosks (JuiceBoxes) to perform a rapid energy exchange. With a battery capacity comparable to that of their phones, the user will be instantly satisfied with the increased longevity of their device.

Market Opportunity

Overall Market Opportunity and the GoJuice Target Market

GoJuice's battery exchange service targets the urban business and college demographics that have long on-the-go days, and rely heavily on their power-hungry smart phones for communication and data transfer. These user groups typically experience consumer nomophobia[1], or the fear of being out of mobile phone contact, as the day progresses and their batteries drain. GoJuice ultimately addresses the consumer's psychological need for always-on communication and desire to be environmentally friendly.

Triple Bottom Line

The three core pillars of GoJuice are sustaining profit, people and environment:

- **Profit:** The GoJuice system has been carefully designed and analyzed to capitalize on a market opportunity that promises to yield high profits in a short period of time. GoJuice investors will benefit from high profit margins.
- **People:** GoJuice is designed to improve customer's lives and day-to-day experiences. The system reduces the time taken to recharge phones and provides a low-anxiety interaction with mobile devices late in the day. GoJuice offers their employees competitive salaries and work environment.
- **Environment:** In addition to the highly visible use of renewable energy to operate kiosks and charge batteries, GoJuice also is deeply rooted in environmentally friendly business practices such as:

replacing paper with electronic ink options, using hybrid corporate vehicles for travel, minimizing energy and carbon footprint, and wind-powered corporate buildings and offices. GoJuice promotes employee commitment to renewable energy via monthly recognition of energy savvy employees.

Market Gap Analysis

The GoJuice case is targeted to create a “mid-tier” mobile phone case market juxtaposed with premium and bottom-tier brands. GoJuice’s mobile phone case will be perceived as a unique, high quality product that supports extended productivity on a renewable energy foundation. Table 1 highlights the main market competition in the phone case with external batteries market space.

Table 1. Current market competitors for phone cases with extra battery life.

Market	Brand	Product	Description	Price
Premium (high quality, high cost)	Mophie[2]	Space Pack	“World’s 1st” extra storage iPhone 5 case 1700 mAh (+120% life): 32 GB Storage	$179.95
	Mophie	Space Pack	“World’s 1st” extra storage iPhone 5 case 1700 mAh (+120% life): 16 GB Storage	$149.95
	Lenmar[3]	Meridian	2-piece design; charging case only 2300 mAh (+160% life)	$89.99
Mid-tier (high quality, low cost)	**GoJuice**	**Swappable Battery Case**	**Removable batter exchange service 1200 mAh (+80% life)**	**$29.99**
Bottom-tier (low quality, low cost)	Aria Accessories[4]	Battery Case	Generic Design 2200 mAh (+150% life)	$14.99

These competitors in the mobile phone charging accessories product space are bifurcated into premium brands (Mophie, Lenmar) that incur premium pricing and bottom-tier products (Aria Accessories) that are simple, low-quality plastic battery phone cases. GoJuice, by contrast, offers a premium product at a bottom-tier price, establishing a new “mid-tier” market. For a price of $29.99, GoJuice customers purchase not only a case, but also free access to a network of charging stations.

GoJuice’s ecosystem approach offers competitive advantage based on the proverb “Time is Money.” Consumers typically place significant value on the time they spend interacting with a product or service. Our value proposition maximizes the consumer value versus time and monetary cost ratio. The phone case purchase cost is amortized over years of free battery exchange service and which requires less than 60 seconds per interaction. Additional perceived value comes from GoJuice's phone app service that locates nearby kiosks and GoJuice business advertisers that offer coupons and discounts.

Pricing Strategy and Customer Value Analysis

Revenue is earned by selling cases and serving advertisements at the GoJuice kiosks. In order to garner increased advertising cost per engagement (CPE) [5][6][7][8], a large and diverse user base must be rapidly built in cities served by GoJuice. The price of the case directly relates to the consumer adoption of the GoJuice case. A focus group of 140 college students was surveyed to examine their value assessment of the GoJuice product. Figure 1 shows the resulting sensitivity of the revenue streams to changes in the selling price of the phone case calculated using the focus group data. In order to simultaneously maximize the user-base and overall case and advertising revenues, a phone case price point is $29.99 is selected.

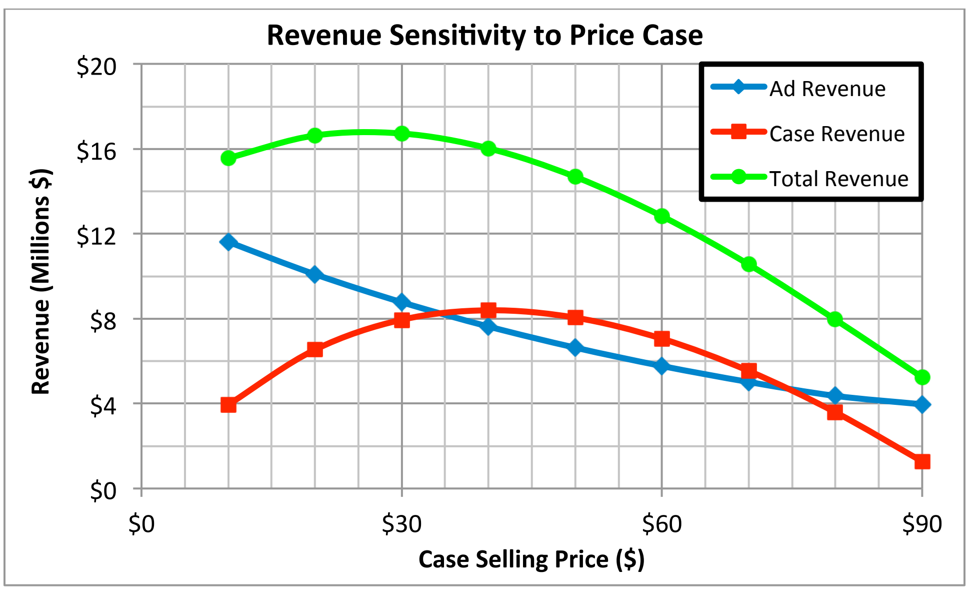


Figure 1. Total GoJuice revenue responding to phone case selling price

Based on the survey, the GoJuice adoption rate among college students is 50% at a selling price of $29.99. At present, 20% of the world population owns a smartphone (60% of the U.S. population)[9], indicating a maximum potential market around 5% of the world population after accounting for demographics. A conservative target of 0.30% adoption in target markets was chosen to estimate revenues and expenses. Appendix A provides further financial analysis for years 2015-2018.

The estimated manufacturing cost per case is $8.14, resulting in a gross unit margin of roughly $20 (i.e., 67%) for the $29.99 case price. Table 2 itemizes the GoJuice phone case manufacturing costs.

Table 2. Estimated manufacturing costs per GoJuice phone case

Item #	Part	Qty.	Unit Price	Cost
1	iPhone 5 case (custom)	1	$ 2.00	$ 2.00
2	3.7 V, 1200 mAh battery	1	$ 1.25	$ 1.25
3	Electronic components	1	$ 1.02	$ 1.02
4	Lightning connector	1	$ 0.37	$ 0.37
5	Minor components & assembly	N/A	N/A	$ 3.50
			Total	$ 8.14

To encourage mass distribution in the early stages of the product cycle, an introductory "early-adopter" case price of $9.99 will be instated. This lower price will promote rapid initial growth and word-of-mouth advertising for the GoJuice service. As the membership grows, the business will be primarily sustained by advertising sales during the kiosk battery exchange service.

Government incentive programs can affect the product pricing by subsidizing the cost of kiosk manufacturing or installation because of GoJuice's positive stance on utilizing green energy sources through its wind turbine and solar panels. The Renewable Electricity Production Tax Credit (PTC) is a federal corporate tax credit program. This incentive credits 2.3¢/kWh for wind power and 1.1 ¢/kWh for solar. [10] Each state varies with its own incentives that will be taken advantage of as well. Providing awareness and encouraging the use of the kiosk, which is powered by green energy sources, will create opportunities to partner with agencies advocating carbon-neutral energy.

Aesthetics and Consumer Appeal

The entire GoJuice system is based on the idea of "juice" as a popular term for battery power, inviting users into a fun, interactive, and modern green energy solution to charge smart phones. The phone cases are referred to as "JuicePacks," while the kiosks are "JuiceBoxes." Figure 2 shows the kiosk and phone case designs. Appendix B contains GoJuice's corporate branding information guide.

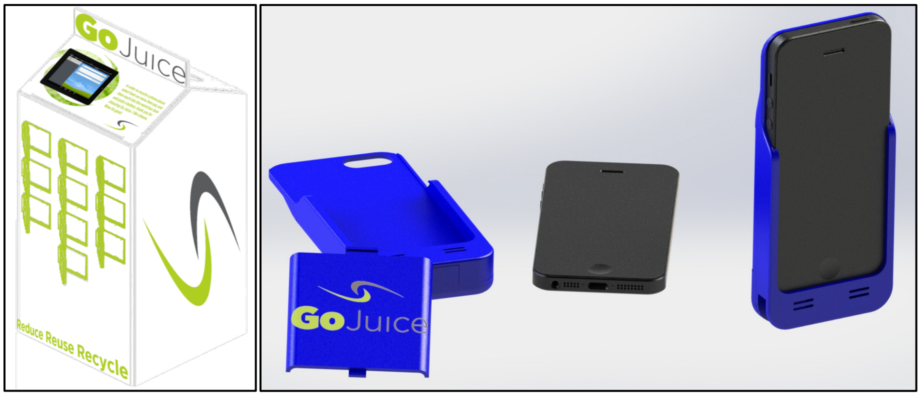


Figure 2. Kiosk "JuiceBox" and Phone Case "JuicePack" Renderings with Integrated Branding

Management Team

The executive management team will comprise a CEO, CFO, and Directors of Engineering & IT, Business Relations, Marketing, and Operations & Maintenance. GoJuice Headquarters will reside in the United States and will oversee all company operations, including accounting and R&D.

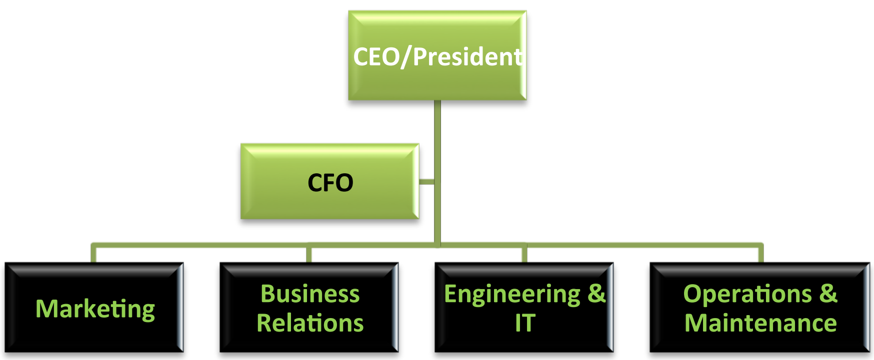


Figure 3. Executive company structure

GoJuice will ultimately be deployed in seven regional markets, including: Northeast United States and Eastern Canada, Southeast United States, Northwest United States and Western Canada, Southwest United States, Asia, Europe, and the Middle East. Each region will have a regional manager and a small operations team to maintain the local GoJuice energy generation and charging station network. The regional managers will oversee: regional operations (i.e., kiosk installations and maintenance), cultural sensitivities, and marketing. The regional managers' teams will consist of marketers and several service technicians. Each marketing team is essential to specifically promote

GoJuice's services and products in their respective region, and to adapt to the local culture, societal and economic trends, and demographics. Managers and employees will be evaluated based on ambitious target metrics for customer base expansion and advertising revenue growth.

Product Development and Corporate Operations

Deployment Activity and Growth

Several major cities in the northeast region of the United States are targets the initial GoJuice deployment. Candidate cities are scored by their overall population, population density, and annual visitors; specific installation locations are determined by analyzing citizen traffic patterns (e.g., metro stations, sporting venues, shopping malls) and by using publicly available metrics (e.g., their "walk score"). Table 3 displays the target cities in order of deployment schedule for the first two years. Rapid adoption of GoJuice will derive from these metro areas; GoJuice kiosks will also be installed in nearby popular tourist and recreational areas, such as beaches, piers, parks and ski-slopes.

Table 3. Target major cities for GoJuice's 2 year deployment plan[11][12][13][14]

Year	City	Stations	Min. Cases	Int./Station	Pop.	Pop. Den. [per mi^2]
1	**Boston**	20	1591	80	636479	12793
	Chicago	85	6787	80	2714856	11842
	New York City	208	20842	100	8336697	27012
	D.C.	23	1581	70	632323	9856
	Philadelphia	48	3869	80	1547607	11397
2	**Seattle**	23	1586	70	634265	7251
	Vancouver	19	1509	80	603502	13590
	San Francisco	23	2065	90	825863	17179
	Las Vegas	25	1491	60	596424	4298
	Dallas	52	3103	60	1241162	3518
	San Diego	56	3346	60	1338348	4020
	San Antonio	58	3457	60	1382951	2880
	Phoenix	62	3722	60	1488750	2798
	Houston	90	5402	60	2160821	3501
	Los Angeles	138	9644	70	3857799	8092

Kiosks will be powered by a variety of renewable energy sources dependent on their location. Kiosks in off-grid areas, such as parks and beaches, will rely exclusively on wind and/or solar sources. Urban kiosks, by contrast, will draw renewables-generated power from the grid and, where possible, be paired with solar panels, which pose minimal risks in an urban environment. Regardless of kiosk location, the energy will be 100% renewably sourced to meet a "green power" guarantee for the customer.

Following initial successes in densely populated U.S. metropolitan centers, GoJuice will quickly expand to the rest of the country. After six years, GoJuice ecosystems will be installed in 20 major U.S. and Canadian cities. In year seven, GoJuice will be deployed to the Asia-Pacific, with large target cities: Singapore, Tokyo, and Seoul, followed by deployment in Hong Kong, Shanghai, and Mumbai. During years nine through fourteen, GoJuice will expand globally across nine major cities in Europe, and in year fifteen two major cities in the Middle East will have a GoJuice network. The deployment plan is in Appendix B.

Marketing Efforts

Market research in each regional business areas is a major component in the operations process. Macro-environmental factors such as demographics, social, technology, economy, and culture will impact GoJuice's business. Young business-persons and college students concentrate within large urban areas, which are local trade hubs and offer a population base with higher average incomes. Social trends, such as online media and smartphone apps, increase the demand for mobile device usage. Technology trends including self-driving cars and "Bucking the Price Norm" may affect consumer purchase and product usage behavior in the coming years. Financial resources are usually available through the city's local government and/or other local organizations. The different cultures and nuances between each region can affect the business of GoJuice. Some areas may be heavily involved in sports, social entertainment, and events, while other areas are more focused on tourism, technology hubs, or agricultural business.

Research and Development

All kiosk, phone, and marketing research and development work will remain in-house to maintain competency and ability to iterate on rapidly developing trends in phone case designs for the mobile industry, in which the typical smartphone product lifecycle is a mere 9 months. The R&D team will work toward improved kiosk energy efficiency to increase the daily battery unit charges using the existing installed capacity. Promising technologies, such as rapid-charge super-capacitors, will be closely watched to assess adoption potential for the GoJuice ecosystem.

Manufacturing

GoJuice will pursue cost competitive kiosk assembly and manufacture, phone case molding, and wind turbine and solar system components. The GoJuice team will design the components – where they add value to the process – and outsource the manufacturing process to specialized companies via an open source bidding process that accounts for ethical labor and environmental practices.

Product Distribution

Distribution of the kiosks and phone cases will be handled via Ryder or other professional transportation services. Kiosks will be installed by regional GoJuice employees. Phone cases will be sold via the kiosk itself, like other electronic device vending machines, and by distribution in select retail outlets including online retailers (Amazon.com, NewEgg.com). Monetary procurement can be sourced externally if possible because of the potential large distances between kiosks.

Financial Analysis

The GoJuice revenue sources are phone cases and advertisements. During the start-up phase of the company, the initial capital is the most important element in the financial statement. GoJuice aims to raise initial venture capital of $3.2 million to fund the estimated first year roll-out. Investors will be offered a stake in the private company, with a 10% stake in exchange for the $3.2 million capital. Based on the estimated revenue of $4.6 million in year one, and a typical P/E ratio of 20, the GoJuice company will be valued at $92.5 million. Hence, the $3.2 million investment will offer investors a (go-) juicy annualized return of 189%. This initial investment will cover costs to produce the phone cases, shipping and installing the kiosks, and employee wages. This venture capital will be utilized to keep manufacturing, packaging, and assembly costs low while maintaining quality for our customers, through outsourcing and bulk manufacturing.

Within the first few years, GoJuice has the potential to make profits in the millions of dollars. Appendices A and B contains the details of this analysis. From the market analysis, GoJuice will still be profitable. With a conservative target of only 0.30% of the population, the result is roughly $4.6 million in revenue, or $1.4 million in profit, in the first year alone. This revenue prediction assumes a conservative 50% user interaction rate of 75 customers per station per day. Cities with a higher than average population density will see higher interaction rates. For example, popular GoJuice sites in New York City are estimated to serve 100-125 interactions per station per day, while cities like Las Vegas or Orlando are estimated at a minimum 75 interactions per station per day. The eight-year profit is estimated at $26.5 million (Appendix B, Tables B5-B7).

Although start-up companies are considered risk-prone, a risk-adverse strategy must be in place when considering the manufacture of the product. International distribution services exist to connect parties whom are interested in foreign manufacturers to take advantage of the relatively low-costs in labor and high-quality products resulting from state-of-the-art manufacturing equipment. However, risks through the supply chain result from the increasing number of participants in the chain. These risks can be mitigated by finding a supplier that is capable of all operations in the manufacturing process. Other risks include but are not limited to: export/import regulations such as tariffs, subcontracting risks, and versatility/flexibility in the manufacturing process for changes in the product design. Frequent scheduled communication between GoJuice and its manufacturing supplier is imperative to reduce these risks as much as possible.

The potential of GoJuice is conceived through the strength of its free battery exchange charging service. Standalone components, base phone cases, and even fully assembled battery cases of a generic design can be purchased from a foreign manufacturer. Table 2 lists the cost of the major components that are required to produce one GoJuice phone case. A conservative estimate of manufacturing cost is $10.00 per case. Competitively positioning GoJuice in the market results in a case selling price of $29.99, an approximately $21.00 gross margin. Appendix A shows the cost analysis.

In a similar manner for the GoJuice kiosk, the cost of manufacture is estimated by comparing between several possible models including a wind powered, solar powered, green energy hybrid, or "plug-in." The scale of both the wind turbine and the solar panels will vary based on installation location. A cost analysis will be performed for each region to determine the scale based on the site-specific wind and sunlight resource. Table B2 lists the estimated costs for each model to determine the weighted average cost for a typical kiosk to be manufactured and installed.

Ad revenue is the primary and lucrative revenue source for GoJuice. The customer will return to the kiosk to exchange for a fully-charged battery almost every day, approximating a subscription-based business model of repeat views of advertisements. Moreover, ads will be sold on high CPE yield from localization of nearby businesses or driven by RFID technology. The GoJuice system, through an RFID system, will collect and request for more information from each user to better serve relevant ads through surveys or user accounts by utilizing a service such as Google Analytics. Video advertisements pay more per exchange based on the consumer engagement. The exchange process can be artificially lengthened to simulate a processing time to create a larger window of advertisement time through the display screen. Keeping users informed of the benefits of using GoJuice's services and their impact on the environment by using green energy will create opportunities for extended interactivity with the consumer. Based on revenue data collected from Facebook and Google, which pursue similar business activities for ad placement, a weighted average of $0.26 per impression is expected.

Local advertisements can possibly pay even more than through digital media means. Partnerships can be considered by allowing discount offers for users of GoJuice to bring in unique customers for nearby local businesses. Another possible option is to allow the GoJuice user to decide themselves which discount to receive, therefore increasing the amount of interactivity and ad influence on the customer. A repeat customer at each kiosk every day creates an enormous number of unique impressions per day in these high-traffic areas, particularly if bystanders and other viewers are interested. Considering initial deployment cities of Boston, Chicago, New York, Washington D.C., and Philadelphia, the weighted average of ad revenue collected from concurrent users generates a daily revenue of $11,000 or approximately $4.0 million per year is expected. Due to the extremely lucrative margins, the downside risk of an optimistic overestimation still leaves sufficient margin for an immediate profit.

Supply chain distribution, installation services, and operation costs are paid from the phone case and advertisement gross margins. The salary structure for GoJuice is kept reasonably low: starting salaries and raises are kept at a minimum. Table 4 shows the starting salary structure and the maximum annual raise percentage for each position. Operations and maintenance salaries vary by location based on the average salary for similar positions. Insurance costs are estimated to be between $2000 and $3000 per city depending on how many stations and batteries are in the GoJuice network for the area.

Table 4. Starting salary breakdown by position

Position	Starting Salary	Max. Annual Raise
CEO/President	$ 70,000	7%
CFO	$ 60,000	7%
Directors	$ 52,500	7%
Regional Managers	$ 47,500	5%
Office Employees	$ 47,500	3%
Ops and Main (US)	$ 40,000	1%
Ops and Main. (Asia)	$ 22,500	1%
Ops and Main (Europe)	$ 47,500	1%
Ops and Main (Middle East)	$ 27,500	1%

Appendix A: Pro-Forma Financial Statements

Table A1. GoJuice Income Statement
For 2015 through 2018
(all numbers in $000)

REVENUE	**2015**	**2016**	**2017**	**2018**
Gross Ad Revenue	$ 3,948	$ 7,971	$ 9,500	$ 16,578
Gross Case Revenue	$ 623	$ 1,258	$ 1,499	$ 2,616
Net Sales	$ 4,571	$ 9,229	$ 11,000	$ 19,194
OPERATING EXPENSES				
Salaries and Wages (inc. benefits)	$ 2,180	$ 4,780	$ 6,091	$ 7,434
Payroll Taxes (about 7.65%)	$ 167	$ 366	$ 466	$ 569
Insurance	$ 3	$ 3	$ 3	$ 3
Rent and Utilities	$ 90	$ 270	$ 360	$ 450
Total Expenses	$ 2,440	$ 5,418	$ 6,920	$ 8,456
Net Income Before Taxes	$ 2,132	$ 3,811	$ 4,079	$ 10,738
Taxes on Income (30%)	$ 1,371	$ 2,769	$ 3,300	$ 5,758
Net Income After Taxes	$ 760	$ 1,042	$ 779	$ 4,980

Table A2. GoJuice Cashflow
For 2015 through 2018
(all numbers in $000)

	2015	2016	2017	2018
Cash Received				
Cash from Operations				
Ad Sales	$3,948	$7,971	$9,500	$16,578
Case Sales	$623	$1,258	$1,499	$2,616
Subtotal Cash from Operations	$4,571	$9,229	$11,000	$19,194
Additional Cash Received				
Sales Tax	$0	$0	$0	$0
New Current Borrowing	$0	$0	$0	$0
New Long-Term Liabilities	$0	$0	$0	$0
Sales of Other Current Assets	$0	$0	$0	$0
Sales of Long-Term Assets	$0	$0	$0	$0
New Investment Received	$0	$0	$0	$0
Subtotal Cash Received	$4,571	$9,229	$11,000	$19,194
Expenditures				
Expenditures from Operations				
Case Manufacturing	$832	$1,680	$2,002	$3,494
Kiosk Manufacturing	$124	$301	$358	$521
Operations/Maintenance Equipment	$2	$5	$6	$8
Subtotal Spent on Operations	$959	$1,986	$2,366	$4,023
Additional Cash Spent				
Salaries	$1,970	$4,150	$5,251	$6,432
Principal Repayment of Current Borrowing	$0	$0	$0	$0
Other Liabilities of Principal Repayment	$0	$0	$0	$0
Long-Term Liabilities Principal Repayment	$0	$0	$0	$0
Purchase of Other Current Assets	$210	$630	$840	$1,002
Subtotal Cash Spent	$3,139	$6,765	$8,457	$11,457
Net Cash Flow	$1,433	$2,464	$2,542	$7,737
Cash Balance	$1,433	$3,897	$6,439	$14,176

Table A3. GoJuice Balance Sheet
For 2015 through 2018
(all numbers in $000)

ASSETS	2015	2016	2017	2018
Current Assets				
Accounts Receivable	$3,948	$7,971	$9,500	$16,578
Inventory	$335	$728	$867	$1,407
Total Current Assets	$4,284	$8,699	$10,367	$17,984
TOTAL ASSETS	$4,284	$8,699	$10,367	$17,984
TOTAL STOCKHOLDER'S EQUITY	$2,104	$3,919	$4,276	$10,550
LIABILITIES				
Current Liabilities				
Accounts Payable	$1,970	$4,150	$5,251	$6,432
Total Current Liabilities	$1,970	$4,150	$5,251	$6,432
Long-Term Liabilities				
Mortgage/Rent	$90	$270	$360	$450
Other long-term liabilities	$120	$360	$480	$552
Total Long-Term Liabilities	$210	$630	$840	$1,002
TOTAL LIABILITIES	$2,180	$4,780	$6,091	$7,434
TOTAL LIABILITY & STOCKHOLDER'S EQUITY	$4,284	$8,699	$10,367	$17,984

Appendix B: Further Financial Analysis and Location Breakdown

Table B1. Location and Expansion 8-Year Plan

City	Stations	Min. Cases	Int./ Station	Pop.	Pop. Den. [per mi^2]	Region	Year to Expand
Boston	24	1909	80	636479	12793	US/Canada	1
Chicago	102	8145	80	2714856	11842	US/Canada	1
New York City	250	25010	100	8336697	27012	US/Canada	1
D.C.	27	1897	70	632323	9856	US/Canada	1
Philadelphia	58	4643	80	1547607	11397	US/Canada	1
Seattle	27	1903	70	634265	7251	US/Canada	2
Vancouver	23	1811	80	603502	13590	US/Canada	2
San Francisco	28	2478	90	825863	17179	US/Canada	2
Las Vegas	30	1789	60	596424	4298	US/Canada	2
Dallas	62	3723	60	1241162	3518	US/Canada	2
San Diego	67	4015	60	1338348	4020	US/Canada	2
San Antonio	69	4149	60	1382951	2880	US/Canada	2
Phoenix	74	4466	60	1488750	2798	US/Canada	2
Houston	108	6482	60	2160821	3501	US/Canada	2
Los Angeles	165	11573	70	3857799	8092	US/Canada	2
Orlando	12	749	60	249562	2327	US/Canada	3
Atlanta	22	1331	60	443775	3154	US/Canada	3
Miami	16	1242	80	413892	11539	US/Canada	3
Montreal	62	4949	80	1649519	11701	US/Canada	3
Toronto	98	7845	80	2615060	10750	US/Canada	3
Singapore	180	16198	90	5399200	19630	Asia	4
Tokyo	218	27215	125	9071577	37715	Asia	4
Seoul	208	31164	150	10388055	44455	Asia	4
Hong Kong	241	21659	90	7219700	16931	Asia	5
Shanghai	595	53508	90	17836133	17728	Asia	5
Mumbai	250	37435	150	12478447	53561	Asia	5
London	312	24925	80	8308369	13688	Europe	6
Moscow	454	36334	80	12111194	12497	Europe	6
Berlin	146	10203	70	3401147	9900	Europe	6
Madrid	121	9647	80	3215633	14000	Europe	7
Barcelona	32	4865	150	1621537	41420	Europe	7
Milan	43	3898	90	1299439	19520	Europe	7
Paris	45	6731	150	2243833	55000	Europe	7
Rome	109	7662	70	2553873	5300	Europe	7
Vienna	60	4796	80	1598626	10366	Europe	7
Riyadh	213	17030	80	5676621	11914	Middle East	8
Istanbul	464	41721	90	13907015	16449	Middle East	8

Table B2. Estimated kiosk manufacturing costs[15][16]

Station Type	Cost	Weight	Weighted Cost
Wind Station	$ 5,700.00	5%	$ 285.00
Solar Station	$ 3,700.00	10%	$ 370.00
Grid Station	$ 1,700.00	65%	$ 1,105.00
Hybrid	$ 4,700.00	20%	$ 940.00
		Total	$ 2,700.00

Table B3. Estimated ad revenue[17]

Ad Type	Cost/ad	Weight	Weighted Cost
Normal Cost	$ 0.05	50%	$ 0.03
Local ads	$ 0.25	30%	$ 0.08
RFID	$ 0.80	20%	$ 0.16
		Total	$ 0.26

Table B4. Example locations for Boston, MA and New York, New York:

Boston Locations	Manhattan Locations	
1. Paul Revere Mall (North End) 2. North Station/Garden 3. Science Park 4. Hatch Shell 5. Public Garden/ Newbury/ Boylston 6. China Town Gate 7. Park Street/ Downtown Crossing/ Suffolk 8. Government Center/ Faneuil Hall 9. Faneuil Hall/ Aquarium/ India Wharf 10. South Station 11. Boston Convention Center 12. World Trade Center/Seaport 13. Mass General 14. Bunker Hill Community College (Charlestown) 15. Boston Common/Public Garden /Beacon/ Charles 16. Boston Public Library/Trinity Church 17. Kenmore/Fenway/BU 18. Prudential/Hynes/Northeastern 19. Prudential/BU 20. Logan Airport	1. Columbia University 2. 1 Line at 110th Street 3. 4-5-6 Line at 110th Street 4. 1-2-3 Line at 96th Street 5. Mt. Sinai Hospital 6. Carl Schurz Park 7. Metropolitan Museum of Art / 4-5-6 Line at 86th Street 8. Roosevelt Park South at 85th Street 9. American Museum of Natural History 10. Hunter College / 4-5-6 Line at 68th Street 11. Rockefeller University 12. Central Park Zoo 13. Lincoln Center for the Performing Arts 14. Ritz Carlton / Central Park 15. Rockefeller Center 16. Times Square North 17. Times Square South 18. Grand Central Station 19. United Nations Headquarters 20. Jacob K. Javis Convention Center	21. Macy's (Southwest corner) 22. Empire State Building 23. Madison Square Garden (Southwest corner) 24. Chelsea Piers 25. Chelsea Park/Highline 26. FIT 27. Madison Square Park 28. Bellevue Hospital Center 29. Jackson Square (Meatpacking District) 30. NYU/Washington Square Park 31. NYU (Northwest corner) 32. Tompkins Square Park 33. 1-2-3 Line at Canal Street 34. Borough of Manhattan Community College / Washington Market Park (Tribeca) 35. World Trade Center 36. Wall Street/NYSE 37. City Hall/Brooklyn Bridge 38. Battery Park 39. NYU Hospital 40. F-M-J-Z Lines at Delancy Street and Essex Street

Table B5. Eight-year cost and revenue projection, based on urban kiosk deployment

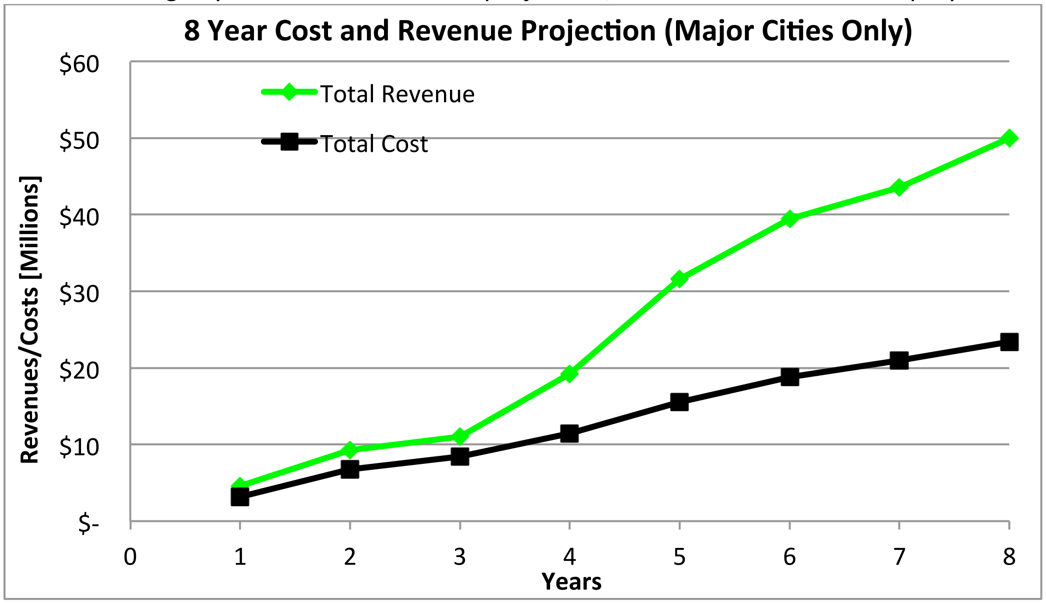


Table B6. Eight-year cost and revenue projection, based on urban kiosk deployment

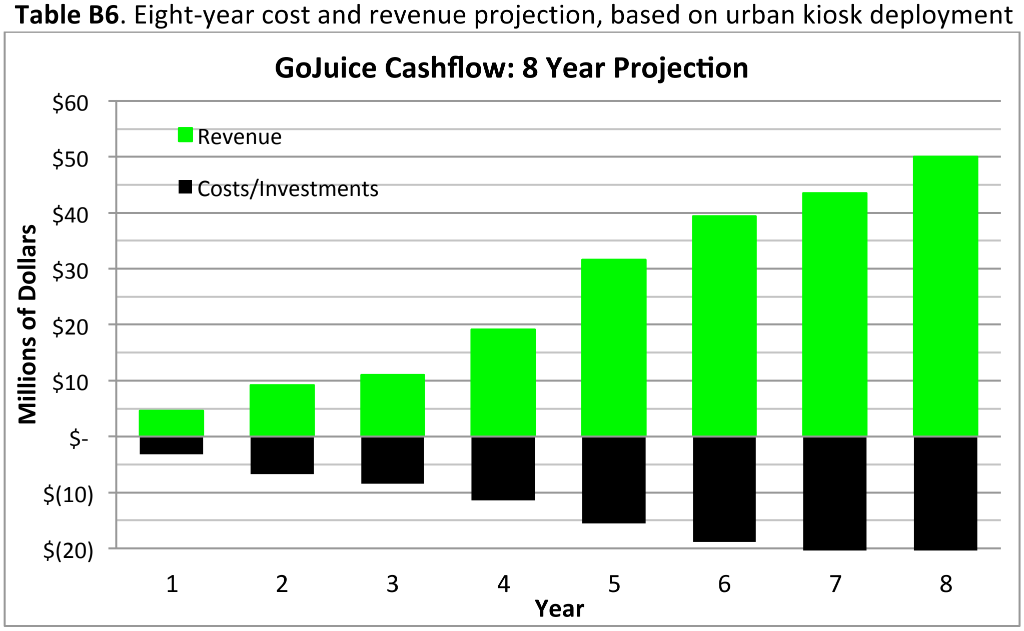
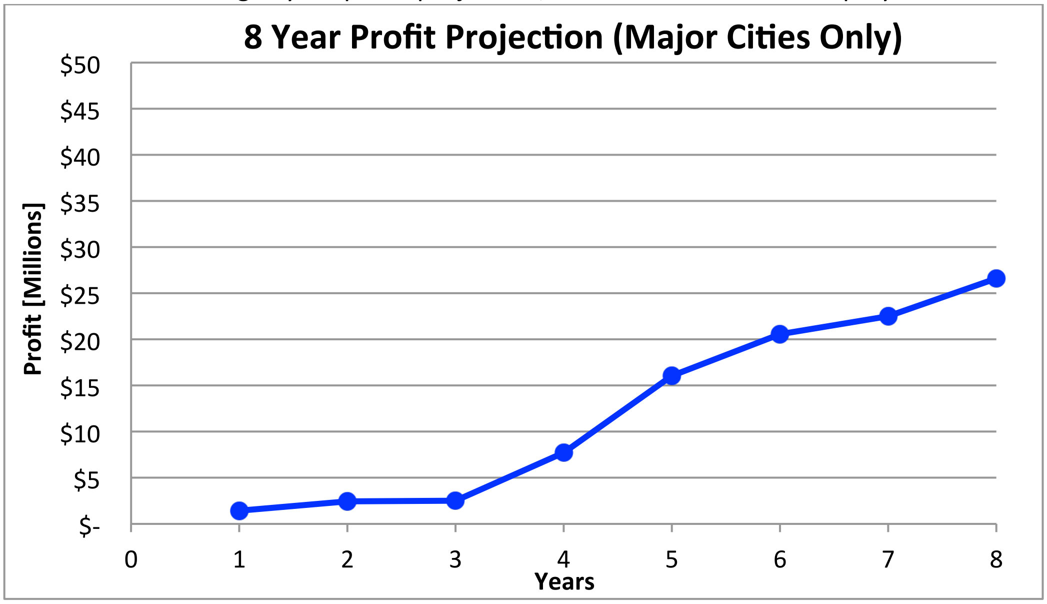


Table B7. Eight-year profit projection, based on urban kiosk deployment



Appendix C: References

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Appendix D: Branding Guide

Attached is an extensive branding guide created for GoJuice.

GoJuice

Identity & Branding Guide

U.S. DEPARTMENT OF ENERGY **(DOE)**

Collegiate Wind Competition

UNIVERSITY OF MASSACHUSETTS LOWELL TEAM

GoJuice

GoJuice

Business Overview

GoJuice's mission is to provide a worry-free wait-free solution to mobile phone charging. GoJuice supports the fast paced rhythm and efficiency of the modern work environment through a unique and interactive phone charging experience that lasts less than one minute. Users will exchange an auxiliary battery from their custom designed GoJuice case with a fully charged battery that will charge the phone on the-go. By adopting the efficient, stylistic and renewables based GoJuice charging system, users will be able to reduce their environmental footprint without making any compromises on quality and their time.

Cellular phone cases containing a removable battery compatible with the market's major smart phone models will be sold and serviced. Consumers will enjoy their personalized, stylish case also functioning as an energy reserve, but with the added capability of instantaneousely recharging their phone. Before or after the day's work, the user will make a quick stop at one of GoJuice's many JuiceBoxes located in their area to exchange their drained case battery for a fully charged one. With a battery capacity equivalent or higher than that of their phones, the user will be satisfied with the increased longevity of their device instantaneously.

Providing a durable and highly functional phone case is one of the many GoJjuice goals. The kiosks passively recharge deposited batteries from the user through renewable energy sources. Advocating renewable energy, GoJuice's kiosks harness both wind and solar power. GoJuice benefits in three major ways: financially through the sales of phone cases and strategic media revenue; socially through the improvement of consumers lives by giving them extra phone power for free; and environmentally through the use of green energy for recharging mobile phones and recyclable materials for phone cases.

GoJuice

Logo-Development

"Logo must convey movement"

"GoJuice needs to be a bold color
different than any other mobile phone or
renewable energy company"

"Logo and Brand need to capture user"

"Target audience is young adult (college)"

"Logo or sign should relate to wind turbine"

"3 blades does not look better than 2 blades"

"Can we animate the logo
to actually show movement"

"relation to human, humanity, green effort"

"renewable energy"

"focus on GO not the juice"

How we got here?

Go Juice

Go Juice
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GO Juice

GOJuice
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GoJuice
GoJuice

Go
Juice

round2

round3
together

Primary Logo

Primary Logo with type

"Logo must convey movement"

"GoJuice needs to be a bold color different than any other mobile phone or renewable energy company"

"Logo and Brand need to capture user"

"Target audience is young adult (college)"

"Logo should relate to wind turbine"

"3 blades does not look better than 2 blades"

"Can we animate the logo to actually show movement"

"relation to human, humanity, green effort"

"renewable energy"

"focus on GO not the juice"

GoJuice

Logo Use & Rules

Safe Area & Isolation Area

Primary Colors

green: #accd37

grey: #5b5b5c

Secondary Colors- On Grey, Green, or other color

white: #fffff

light-grey: # edecec

Unacceptable Use of logo & brand

color

stretched-warped

incomplete

position-violates isolation

GoJuice

Brand in context


GoJuice


GoJuice
GoJuice
Juice Up!


GoJuice


GoJuice
Kristin Morrissey- Designer
978-726-0208


GoJuice
Juice Up!

GoJuice

User Interface & App Overview

Kiosk users are first identified by the user interface as they approach the station using the RFID tag embedded in the GoJuice phone case. The auxiliary battery exchange is performed efficiently (< 1 minute) with minimal user interaction. During the battery exchange, the customer views a targeted interactive advertisement streaming on the kiosk's low-power touchscreen.

A detailed user experience flowchart is provided in Figure 6. The user experience is augmented by downloading the optional GoJuice phone application, which provides:

(1) a synopsis of the environmental impact of phone charging behavior; (2) the locations of nearby GoJuice stations; and (3) storage of electronic coupons served by GoJuice. Other potential involvement with the customer is to allow them to choose which ad is appealing to them.

This can lead to exclusive offers such as discounts or promotions to establishments or other products that the consumer would like to receive, further enhancing the experience of good service.

To provide user-interactivity, a touchscreen display, such as an iPad, will be used to handle all transactions. Internal to the kiosk, an automated robotic receiving mechanism will accept the customer's batteries and delivers them to an H-frame charging assembly. Subsequently, a fully charged battery is removed from the charging assembly and placed into a pick-up slot. A wireless access point will also be installed to provide network connectivity to the consumer.


GoJuice
Juice Up!


GoJuice
Reduce Reuse Recycle
GoJuice
Reduce Reuse Recycle

GoJuice

Kiosk Overview

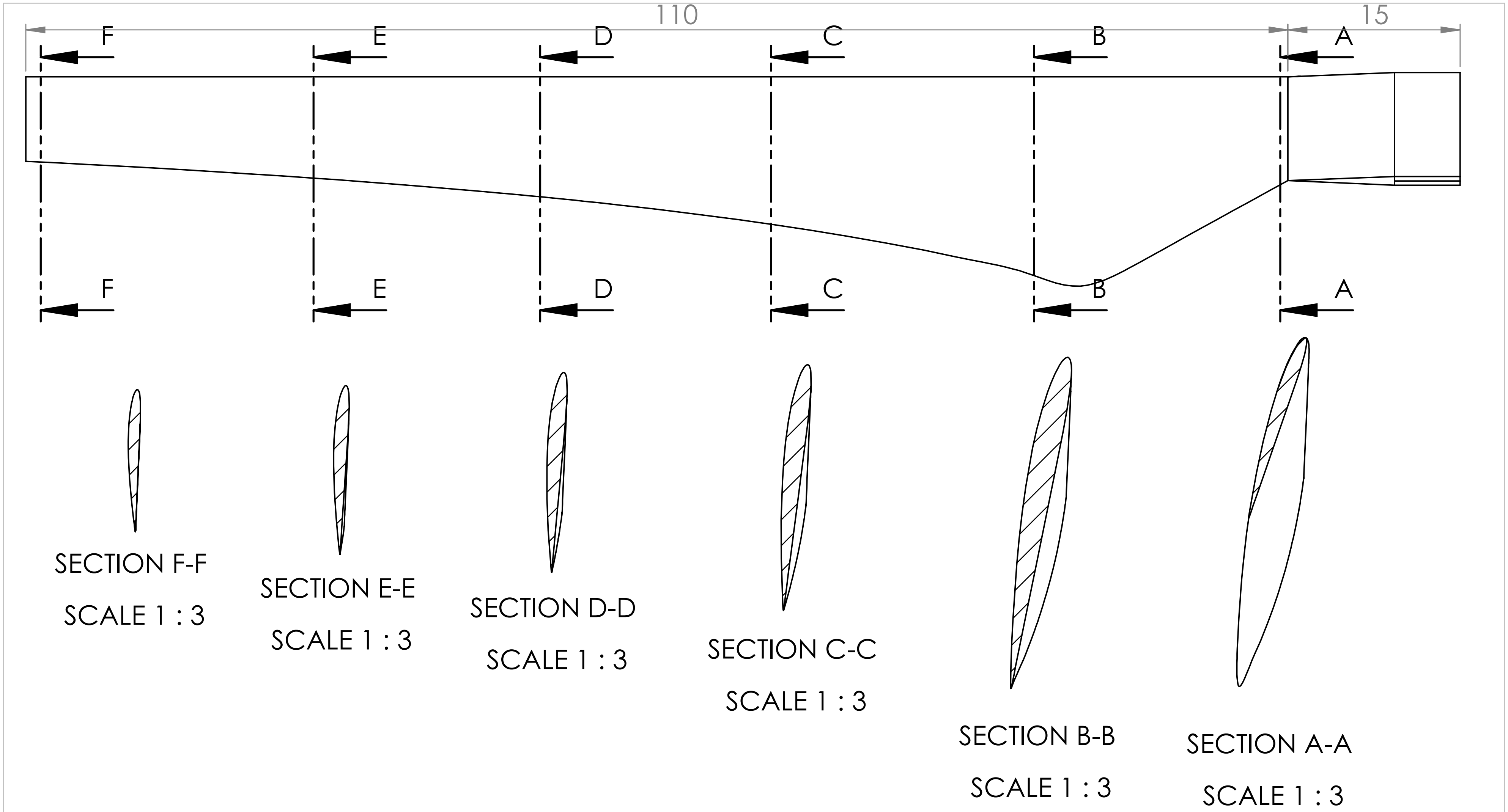
The primary goals of the **GoJuice kiosk** are (1) to provide an effective user experience through a professionally-designed, interactive user interface; (2) to provide a nearly instantaneous auxiliary mobile phone battery exchange; (3) to protect and recharge auxiliary and station batteries both outdoors and indoors; and (4) to provide a fourth generation internet connection between the station and GoJuice's user database/advertisement servers. A team of 3 were tasked for the concept, design, user-interface and interaction, and construction of the GoJuice kiosk.

kiosk prototype

Appendix E: Specifications for the Full Scale Turbine

Attached are the Specifications for the Full Scale Turbine.

Large Scale Turbine



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ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

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MFG APPR.		
Q.A.		

COMMENTS:

GO JUICE

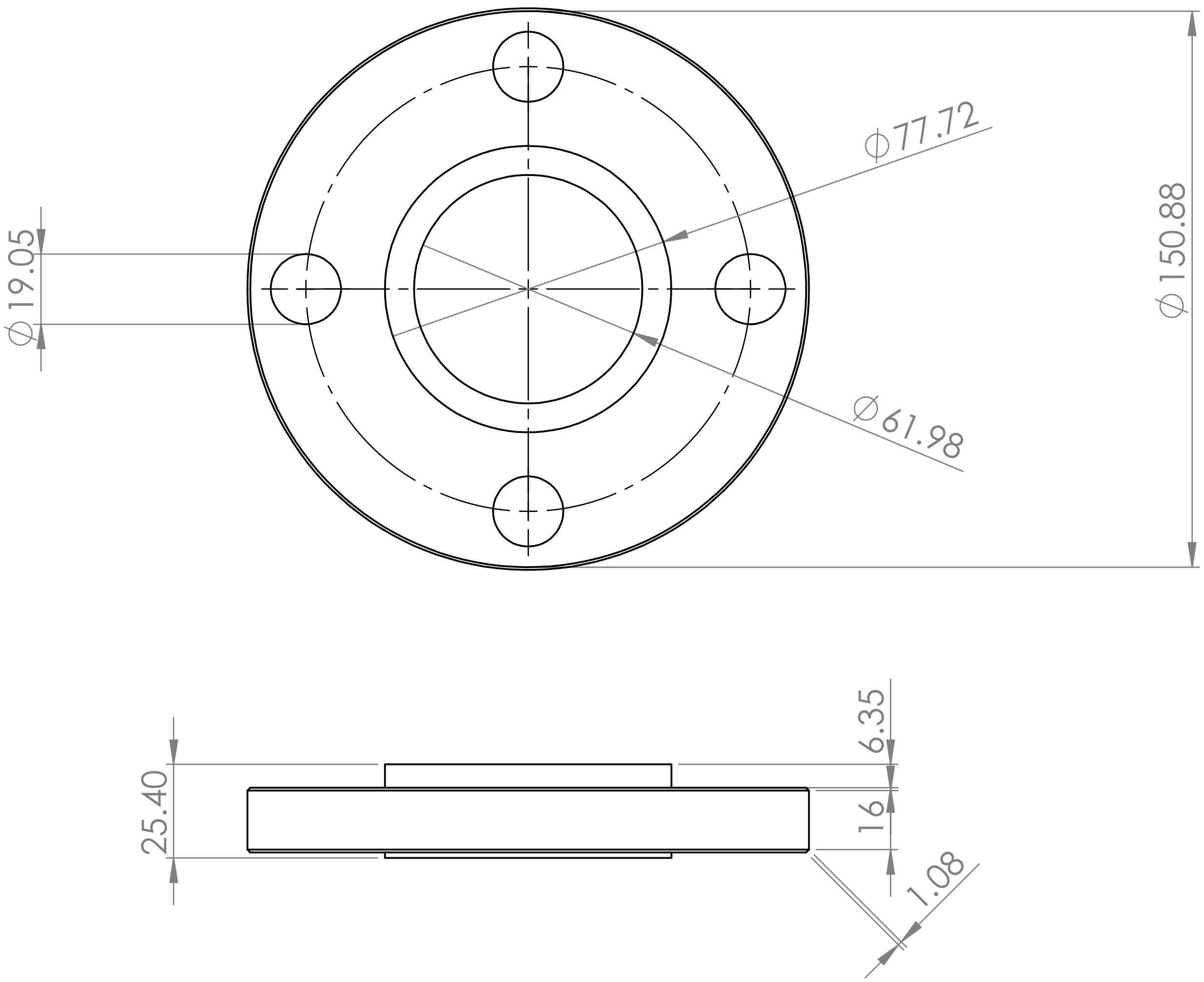
TITLE:

NACA 2414

SIZE	DWG. NO.	REV
A	1	

SCALE: 1:20 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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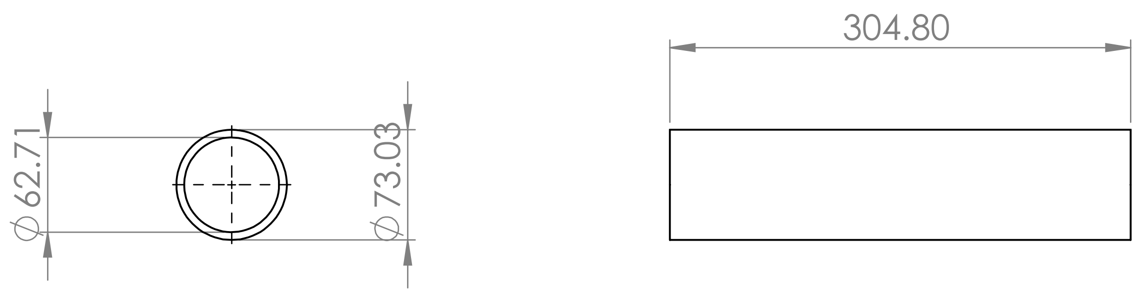
Q.A.		
COMMENTS:		

TITLE:

Large Flange

SIZE	DWG. NO.	REV
A	68095K135_Flange	
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



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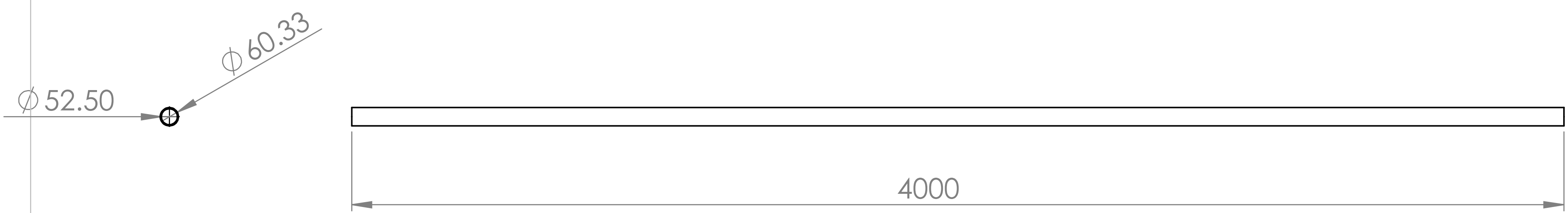
TITLE:

Sleeve

SIZE A | DWG. NO. 750K117_Collar | REV

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



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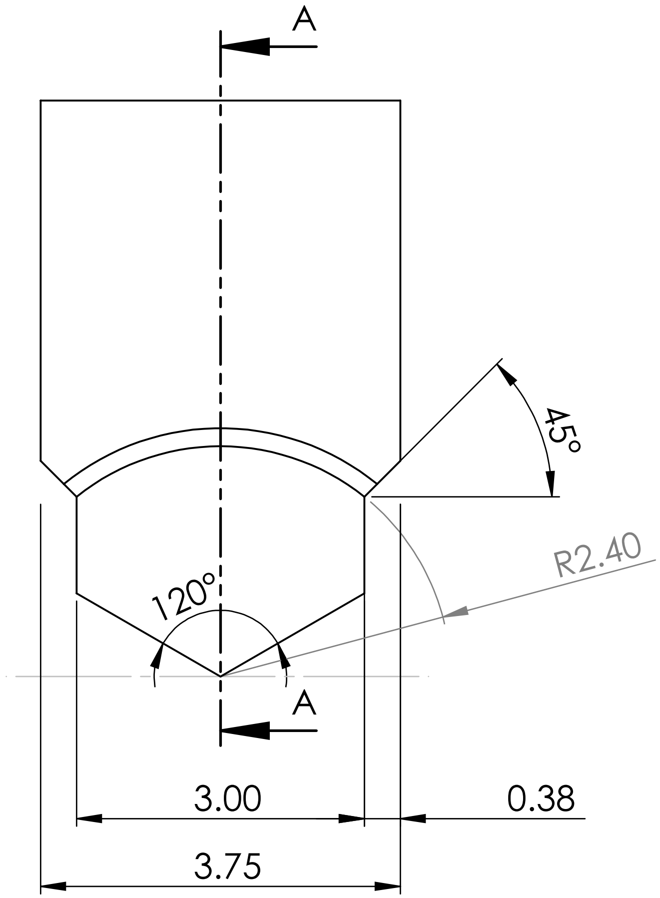
TITLE:

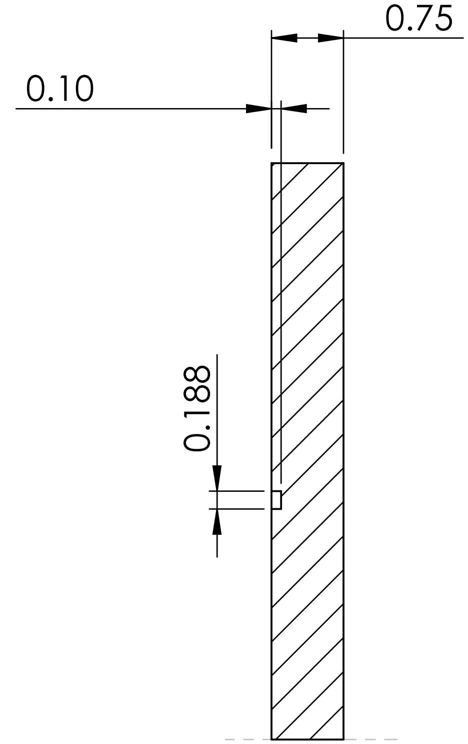
Pipe

SIZE	DWG. NO.	REV
A	7750K196_Pipe	

SCALE: 1:50 WEIGHT: SHEET 1 OF 1

5 4 3 2 1





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COMMENTS:

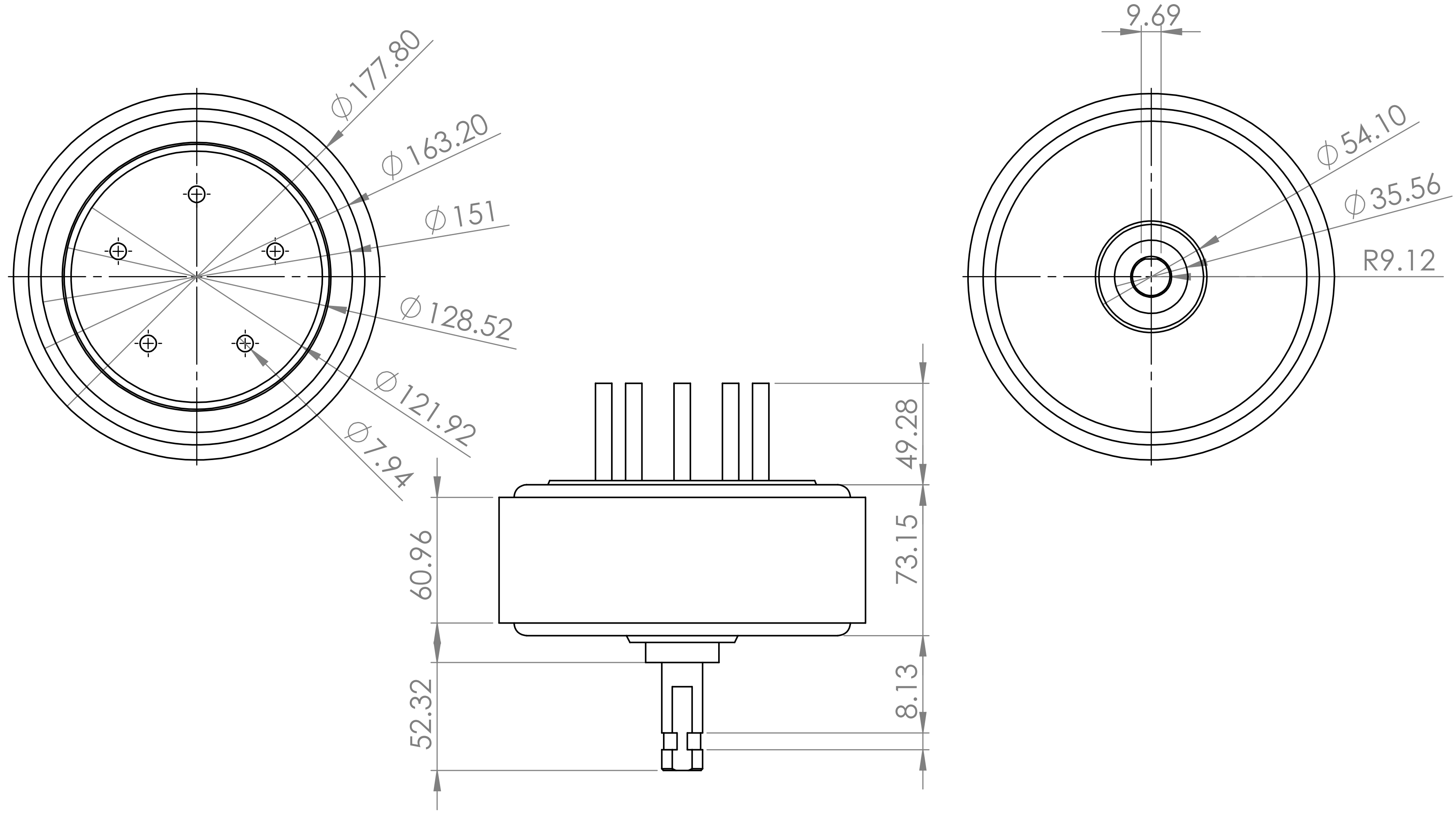
TITLE:

BLADE STUB

SIZE	DWG. NO.	REV
A	1	0

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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COMMENTS:

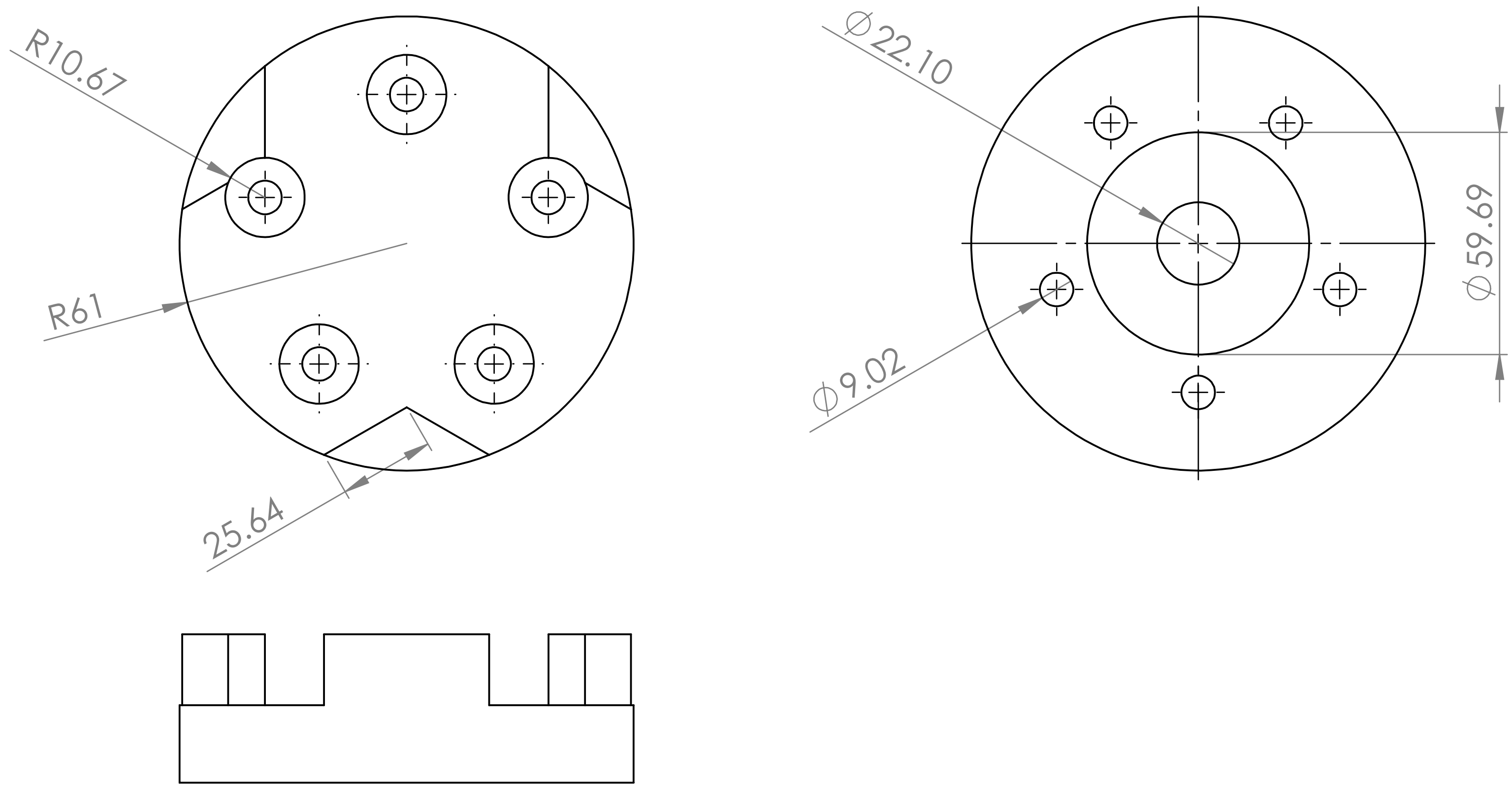
TITLE:

Generator

SIZE **A** DWG. NO. Generator REV

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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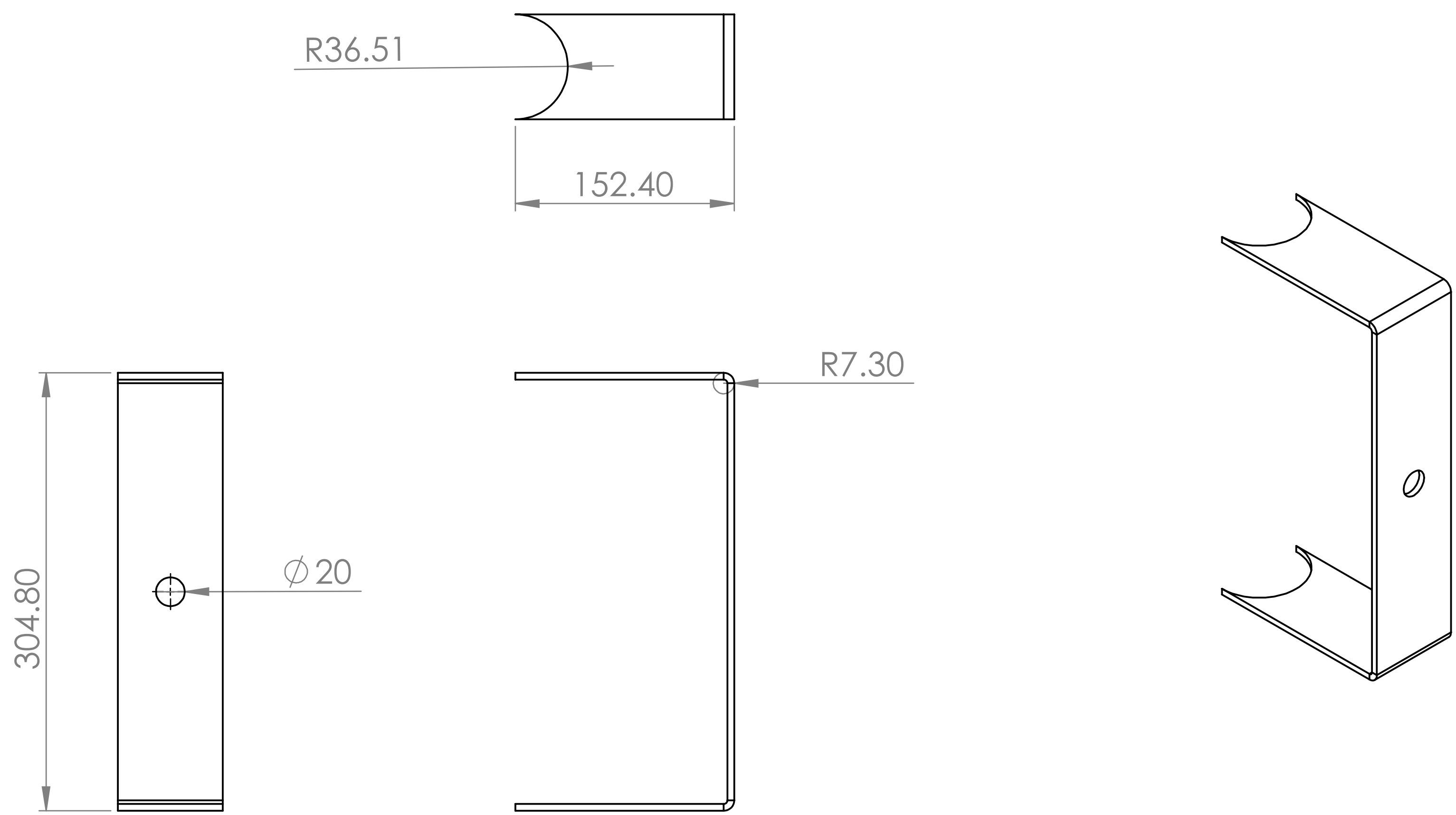
TITLE:

Hub

SIZE A | DWG. NO. Hub | REV

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



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TITLE:

Sleeve Subassembly

SIZE: A | DWG. NO.: Sheet Metal | REV

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 1

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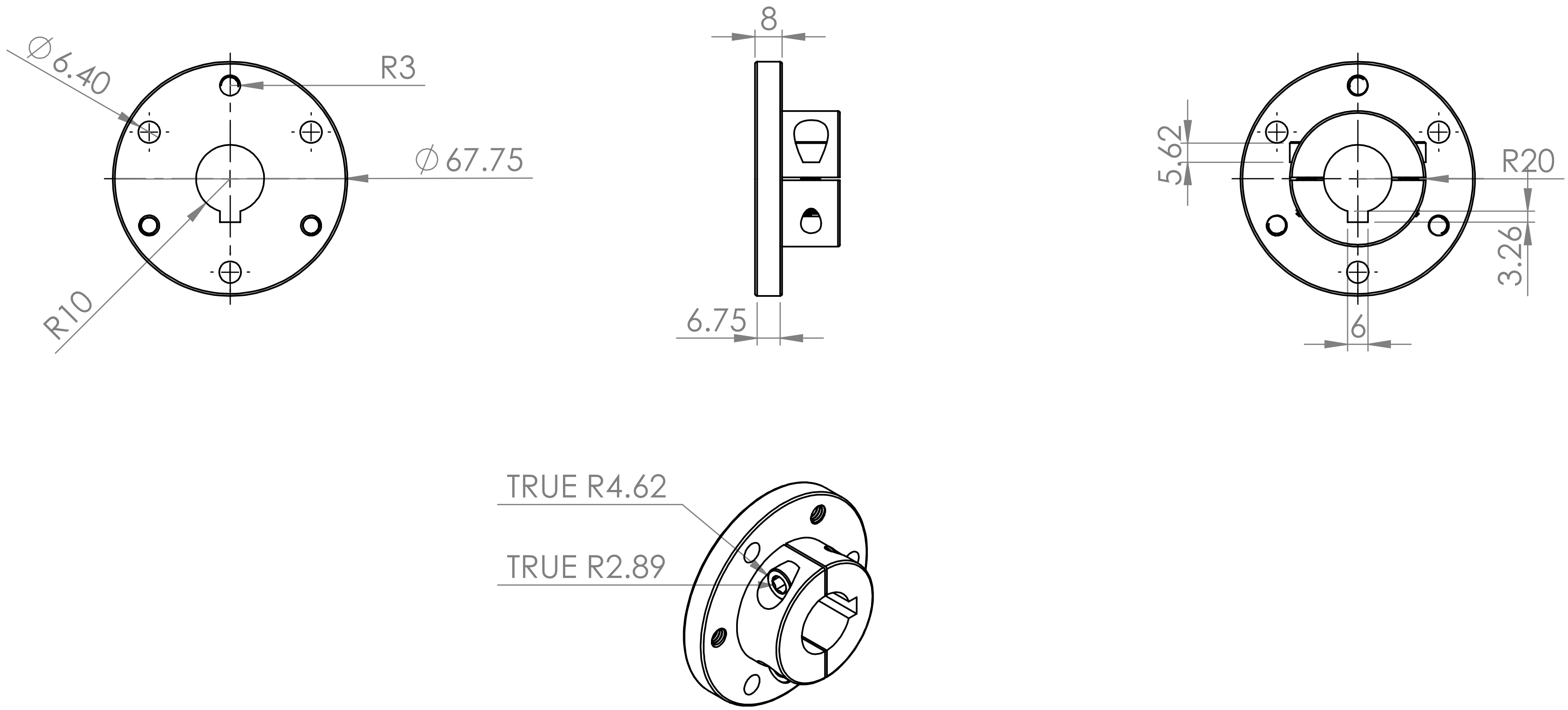
5 4 3 2 1



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APPLICATION		DO NOT SCALE DRAWING

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COMMENTS:		

TITLE:

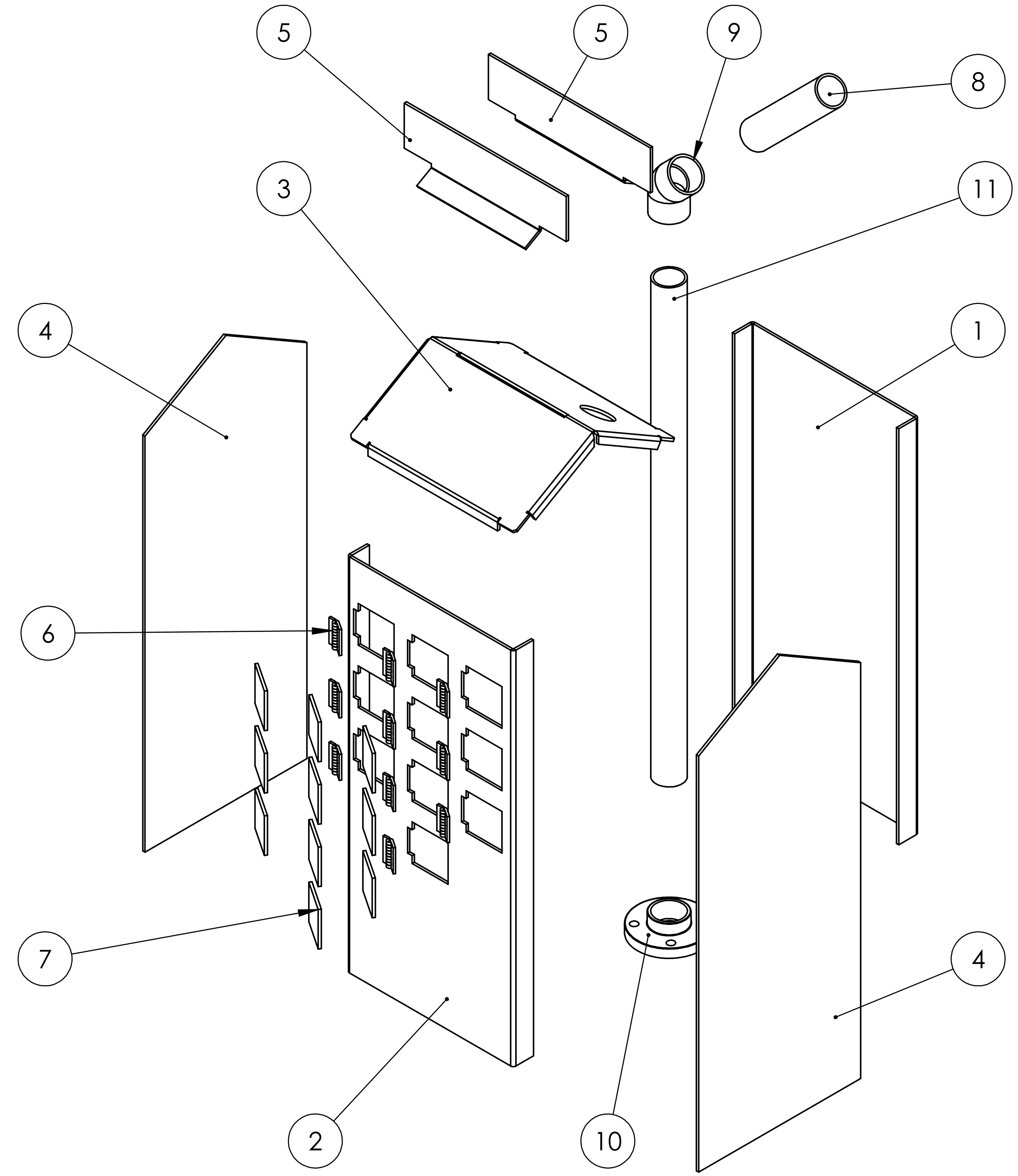
Small Flange

SIZE A | DWG. NO. Small Flange | REV

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

Kiosk Drawings



ITEM NO.	PART NUMBER	QTY.
1	Back Panel	1
2	Front Panel	1
3	Roof Panel	1
4	Side Panel	4
5	Top Panel	2
6	Hinge	10
7	Door Panal	10
8	1 Ft. PVC Pipe	1
9	45 Deg. Elbow	1
10	PVC Flange	1
11	4 Ft. PVC Pipe	1

UML GO Juice

TITLE: Kiosk Assembly

UNLESS OTHERWISE SPECIFIED:
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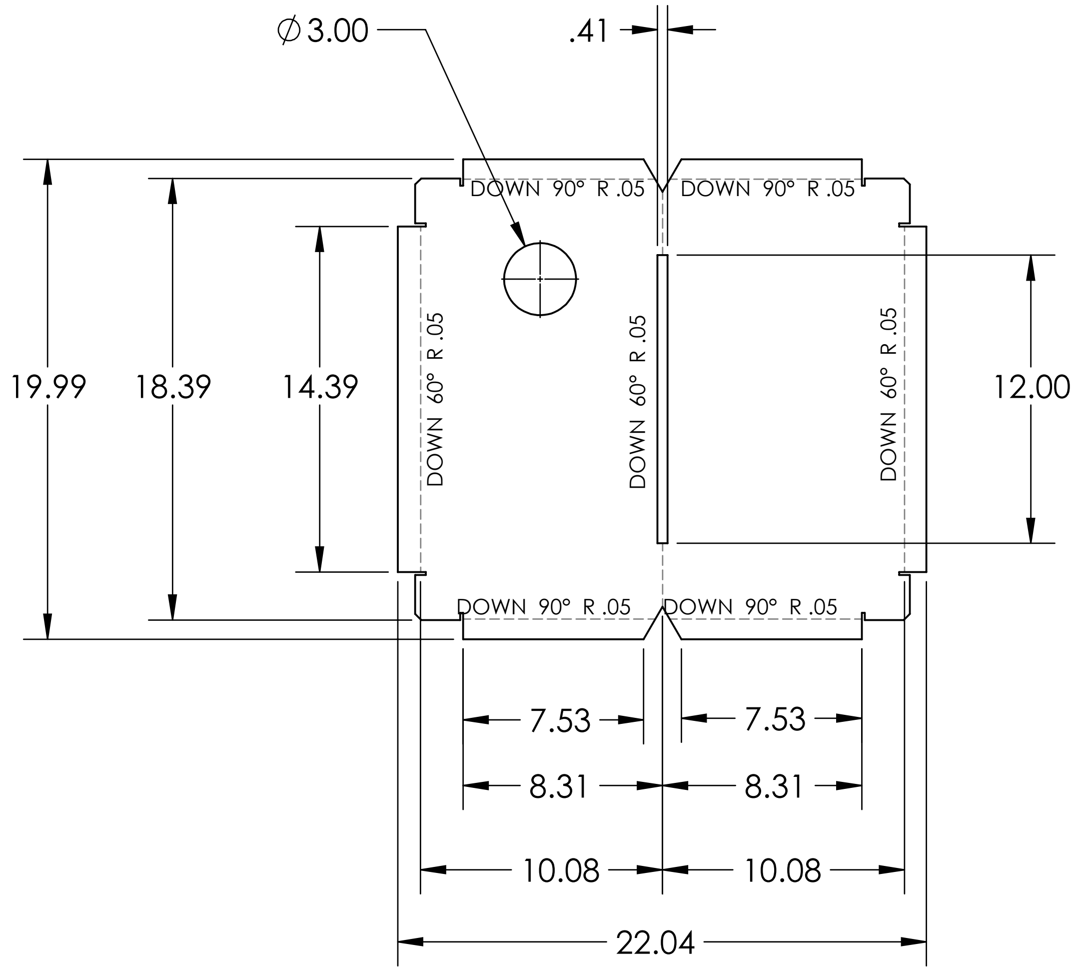

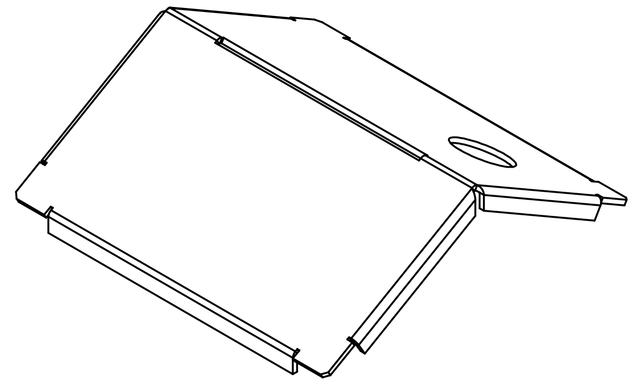

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UML GO JUICE

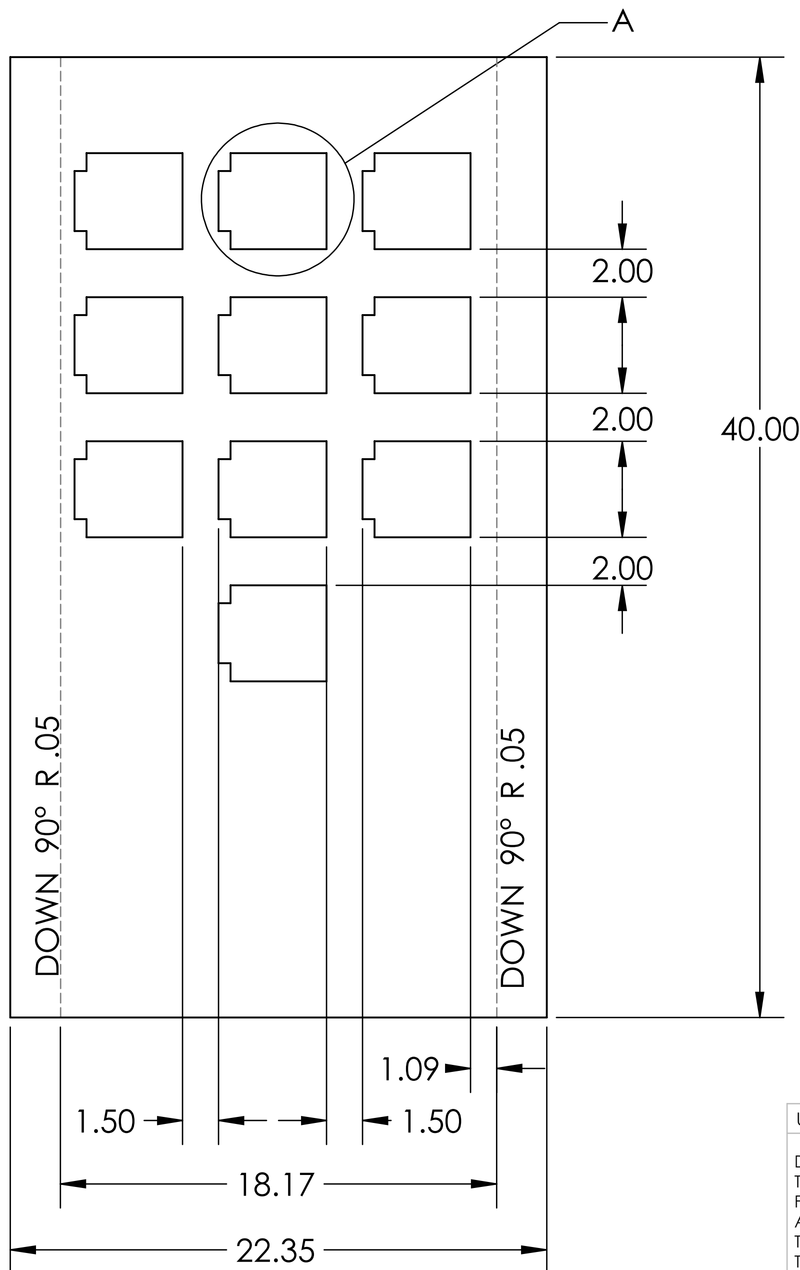
TITLE:

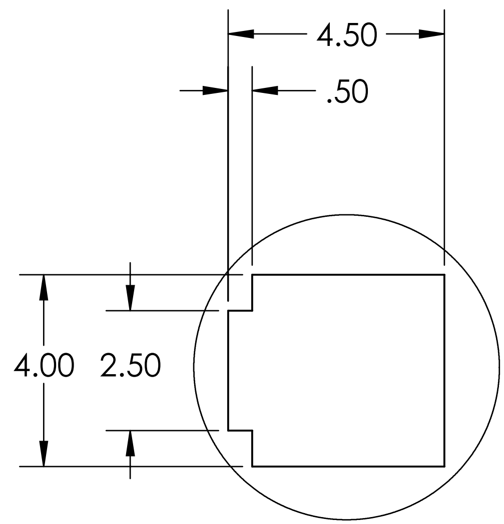
Roof Panel

SIZE **A** DWG. NO. REV

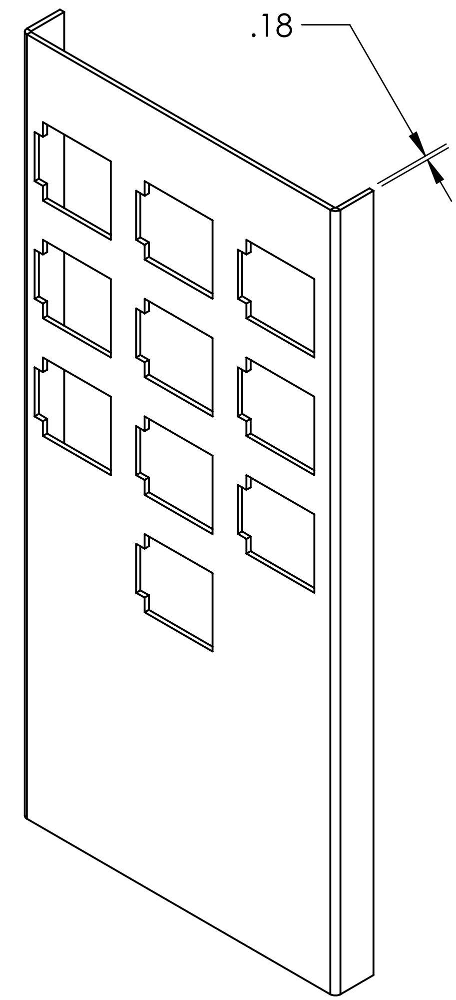
SCALE: 1:8 WEIGHT: SHEET 2 OF 10

5 4 3 2 1





DETAIL A
SCALE 1 : 4



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INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
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PROPRIETARY AND CONFIDENTIAL

UML GO JUICE

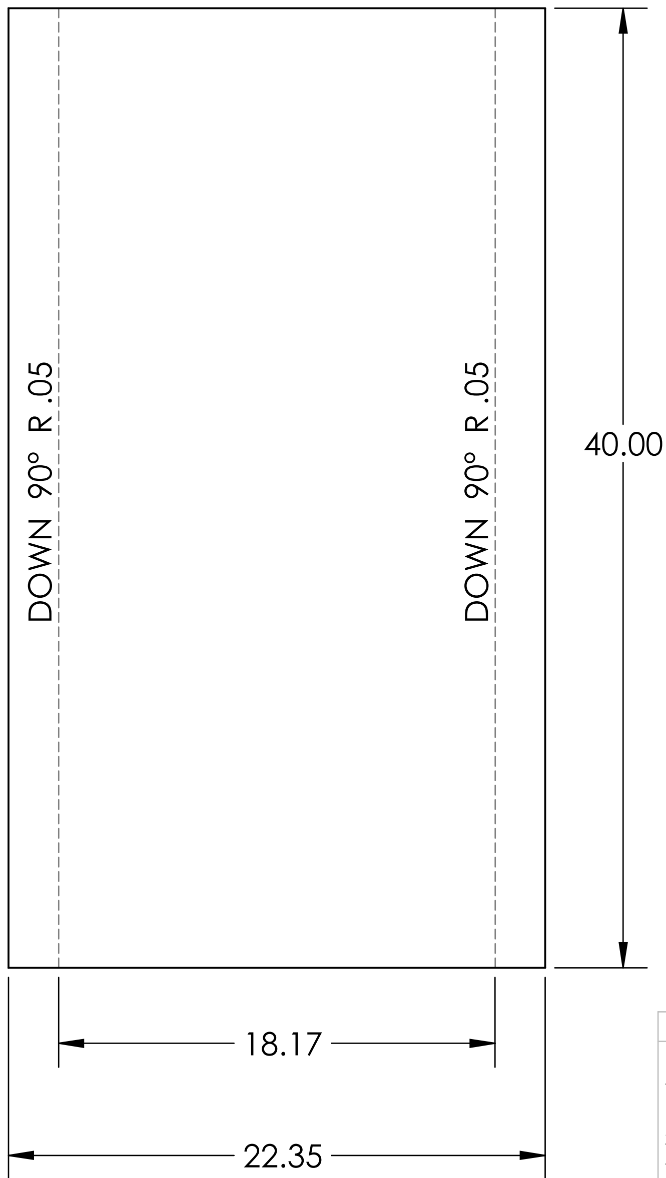
TITLE:

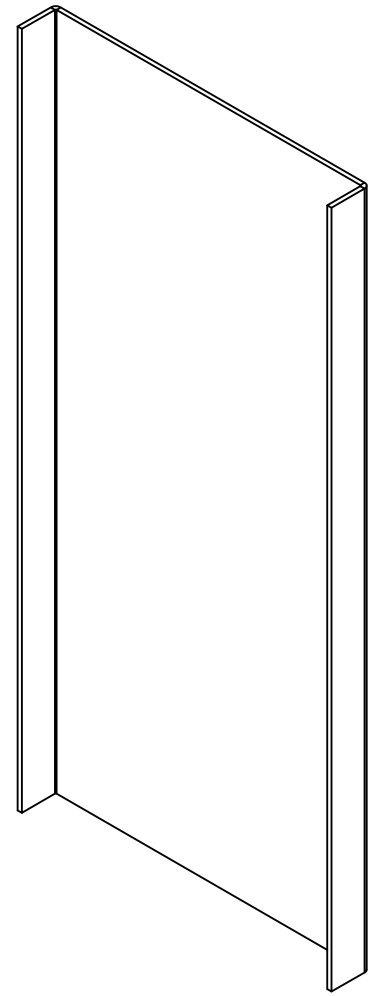
Front Panel

SIZE	DWG. NO.	REV
A		

SCALE: 1:8 | WEIGHT: | SHEET 3 OF 10

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	PP	4.11.14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UML GO JUICE

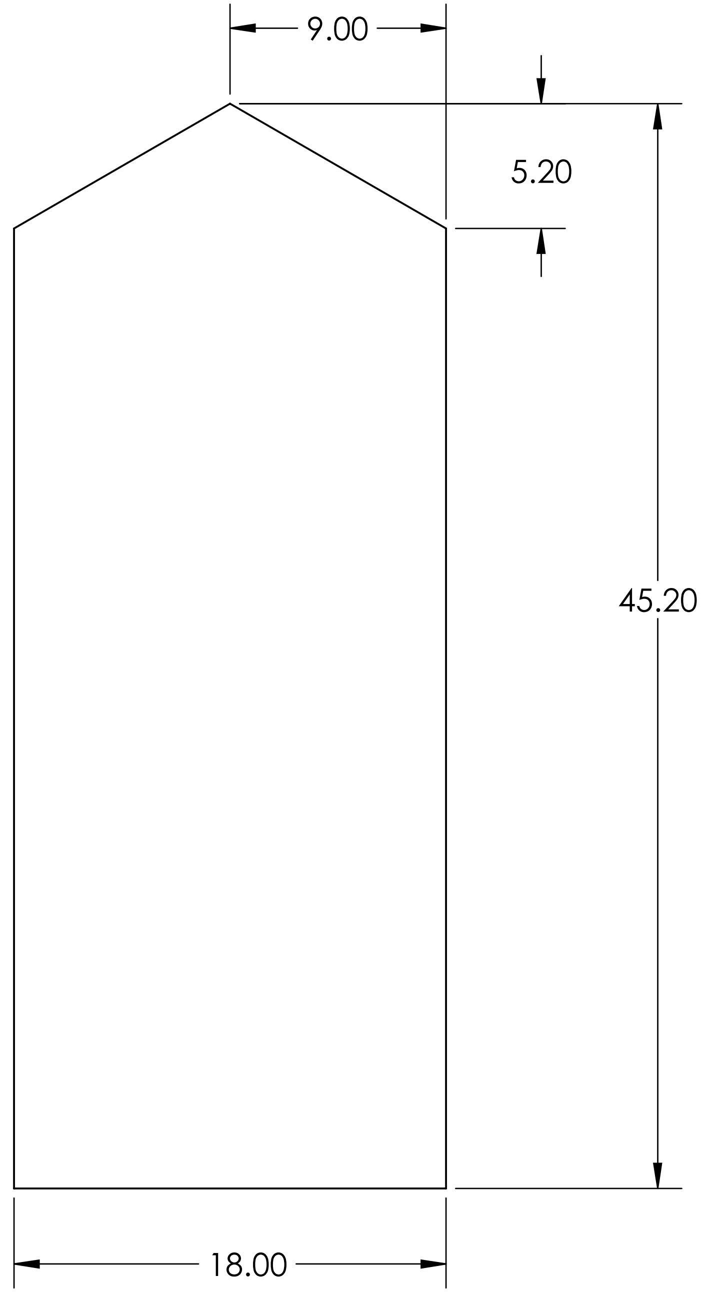
TITLE:

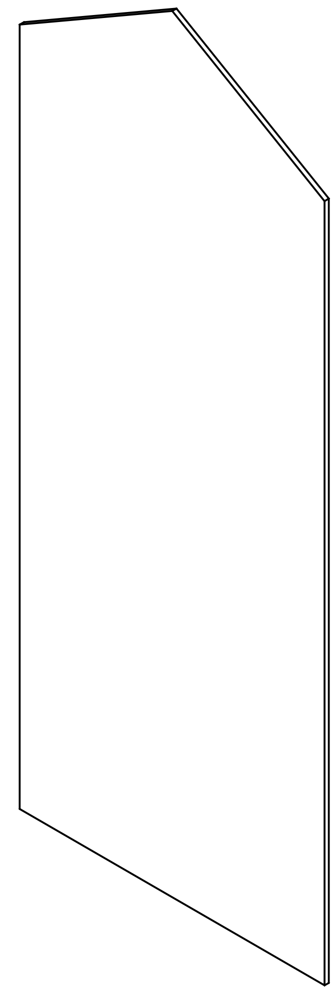
Back Panel

SIZE	DWG. NO.	REV
A		

SCALE: 1:8 WEIGHT: SHEET 4 OF 10

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	PP	4.11.14
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

UML GO JUICE

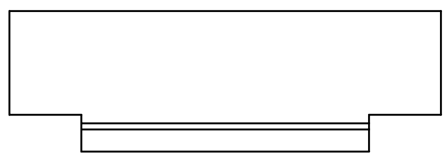
TITLE:

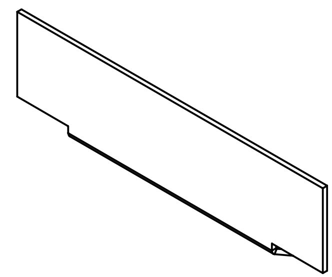
Side Panel

SIZE	DWG. NO.	REV
A		

SCALE: 1:8 | WEIGHT: | SHEET 5 OF 10

5 4 3 2 1





PROPRIETARY AND CONFIDENTIAL

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UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	PP	4.11.14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UML GO JUICE

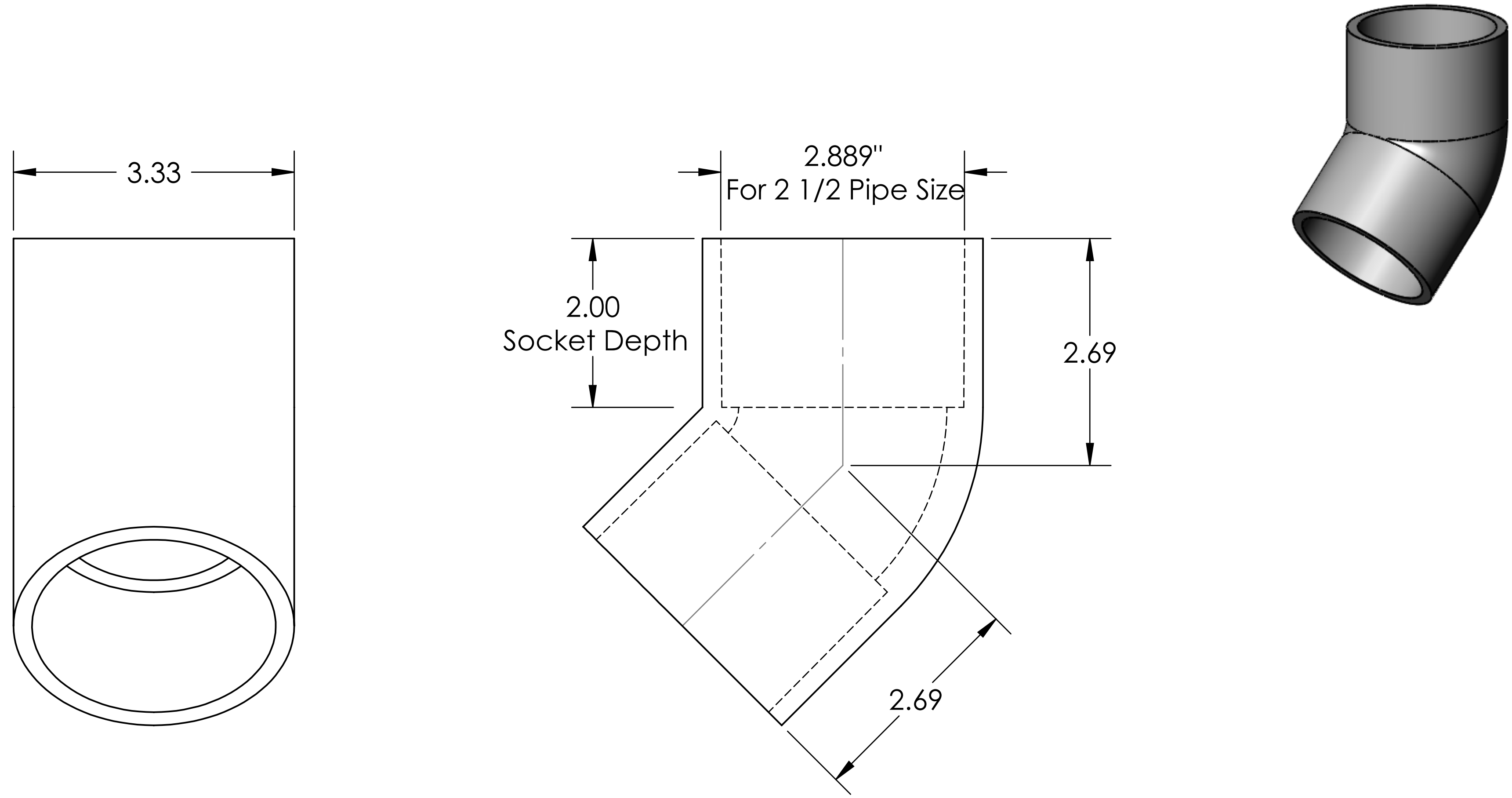
TITLE:

Front Panel

SIZE **A** DWG. NO. REV

SCALE: 1:8 WEIGHT: SHEET 6 OF 10

5 4 3 2 1



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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	PP	4.11.14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UML GO JUICE

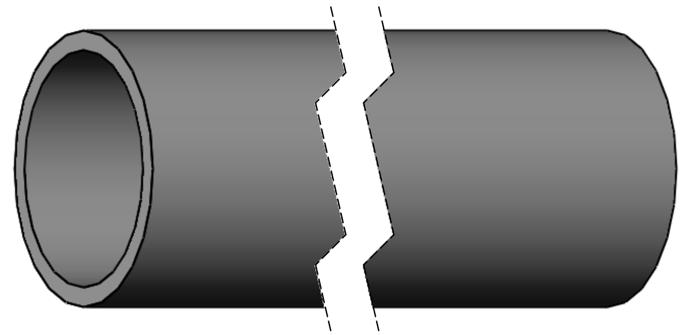
TITLE:

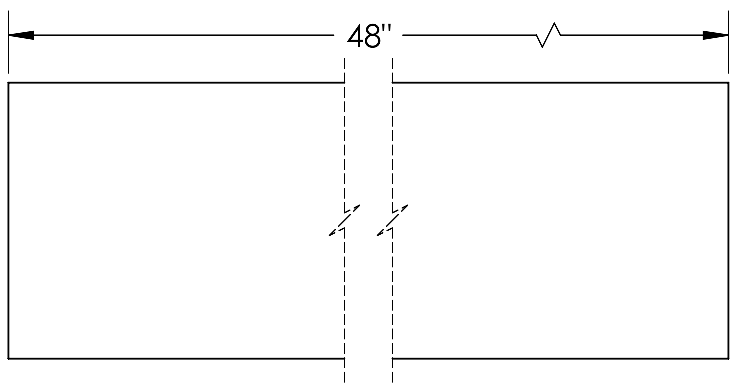
45 Degree PVC Elbow

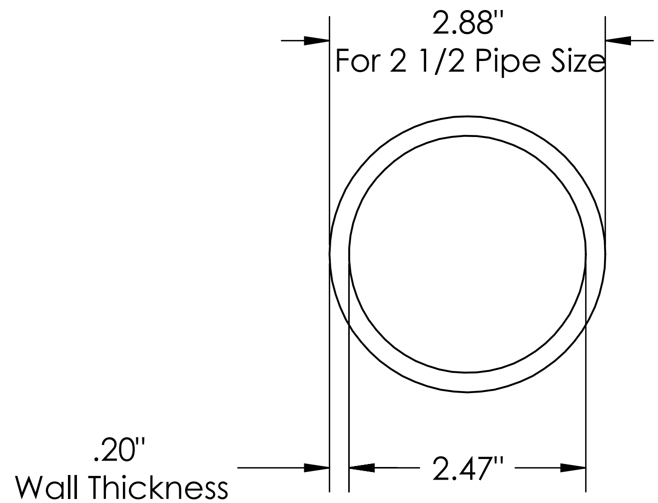
SIZE A | DWG. NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 7 OF 10

5 4 3 2 1







UNLESS OTHERWISE SPECIFIED:		NAME	DATE
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	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

UML GO JUICE

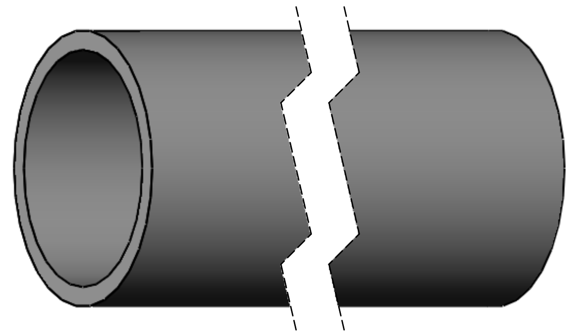
TITLE:

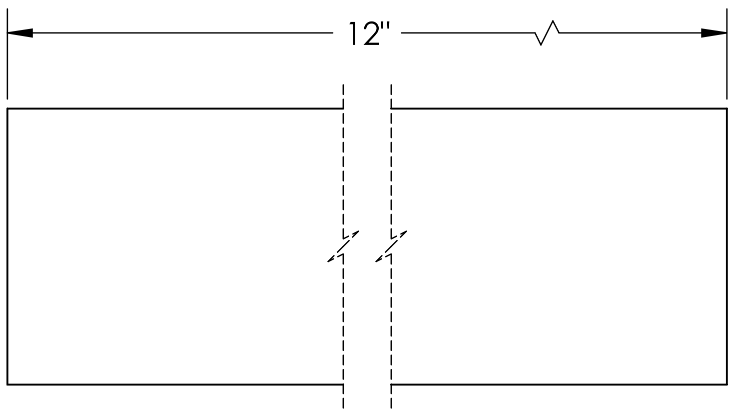
4 Foot PVC Pipe

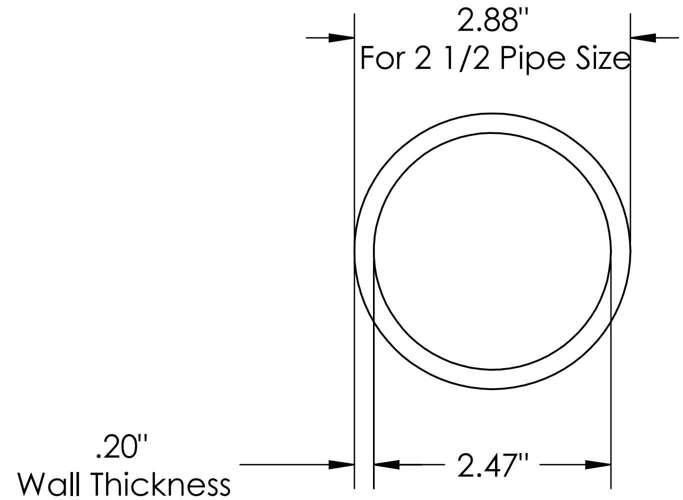
SIZE	DWG. NO.	REV
A		

SCALE: 1:2 WEIGHT: SHEET 8 OF 10

5 4 3 2 1







UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	PP	4.11.14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UML GO JUICE

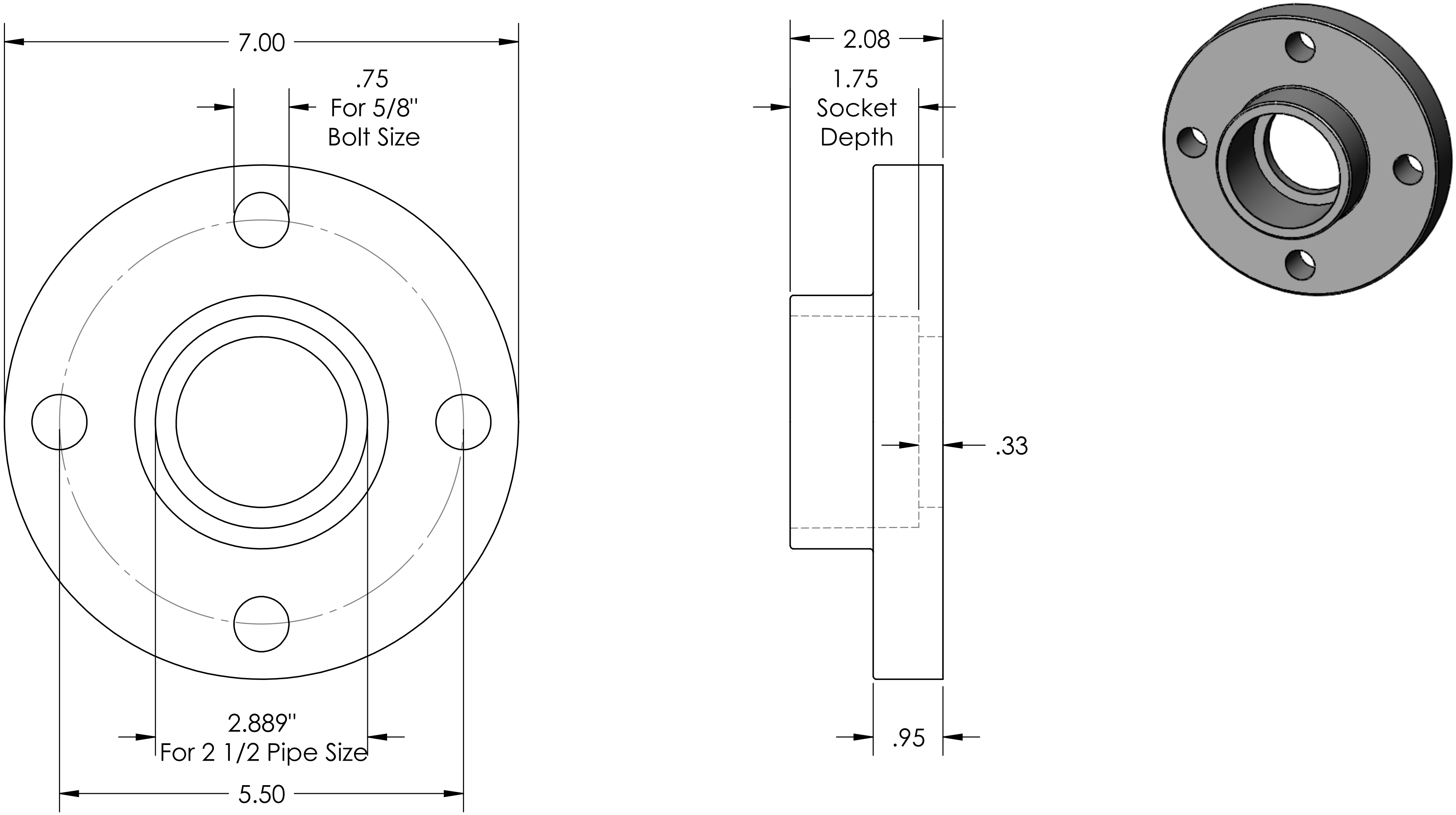
TITLE:

1 Foot PVC Pipe

SIZE A | DWG. NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 9 OF 10

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	PP	4.11.14
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

UML GO JUICE

TITLE:

PVC Pipe Fitting

SIZE **A** DWG. NO. REV

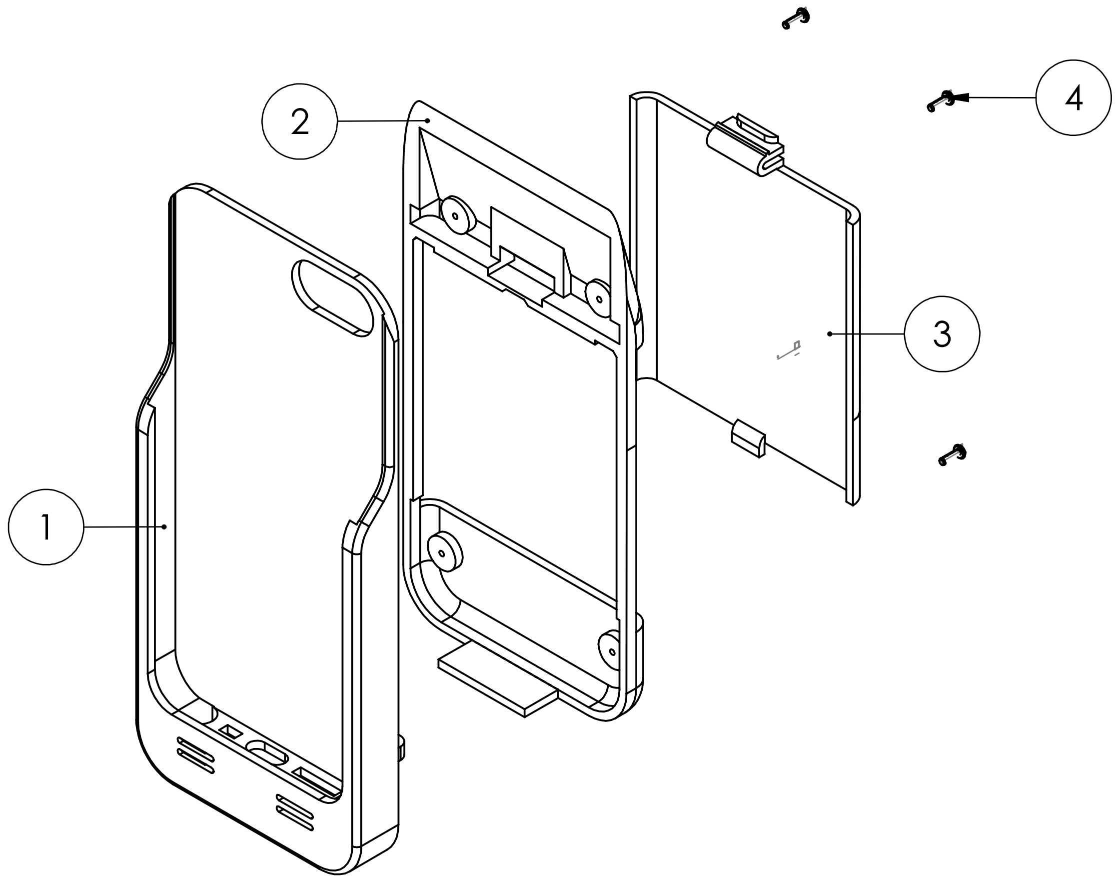
SCALE: 1:2 WEIGHT: SHEET 10 OF 10

PROPRIETARY AND CONFIDENTIAL

5 4 3 2 1

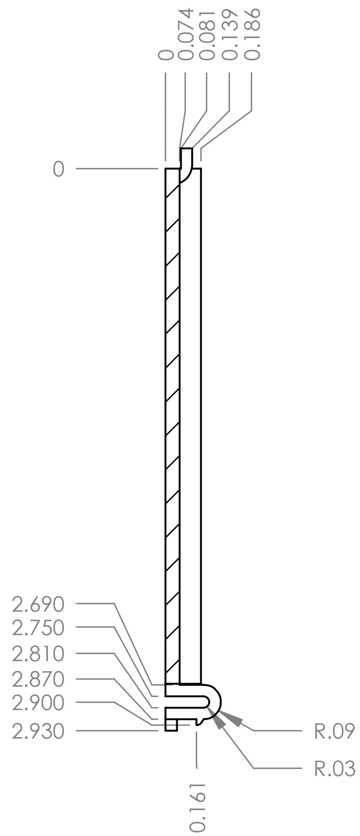
Phone Case Drawings

ITEM NO.	PART	QTY.
1	IPHONE CASE TOP	1
2	IPHONE CASE BOTTOM	1
3	BATTERY COVER	1
4	#0-80 x 3/16" screw	4

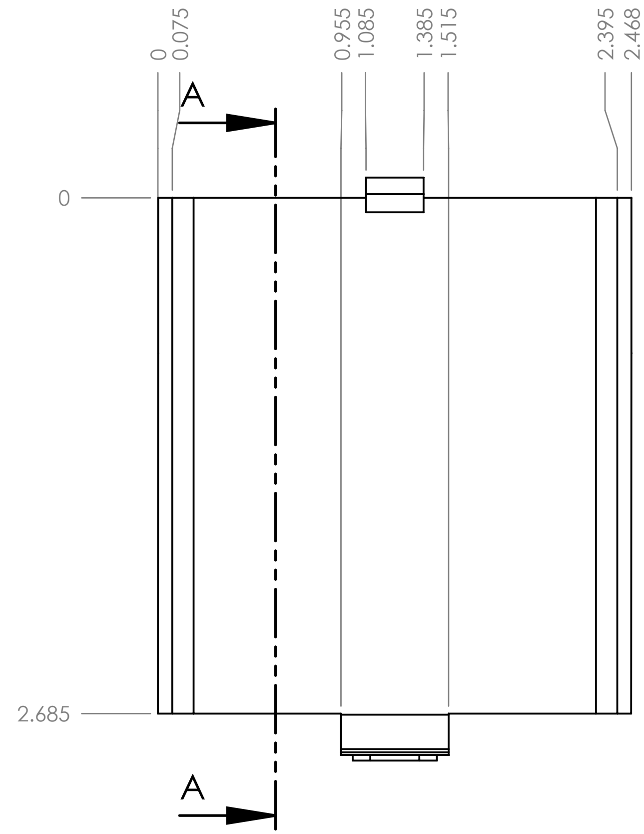


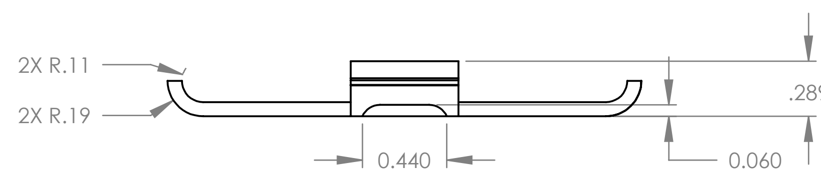
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GO JUICE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	JC	3.19.14	TITLE: iphone 5 phone case assembly
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A · DWG. NO. · REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:1.5 · WEIGHT: · SHEET 1 OF 1

5 4 3 2 1



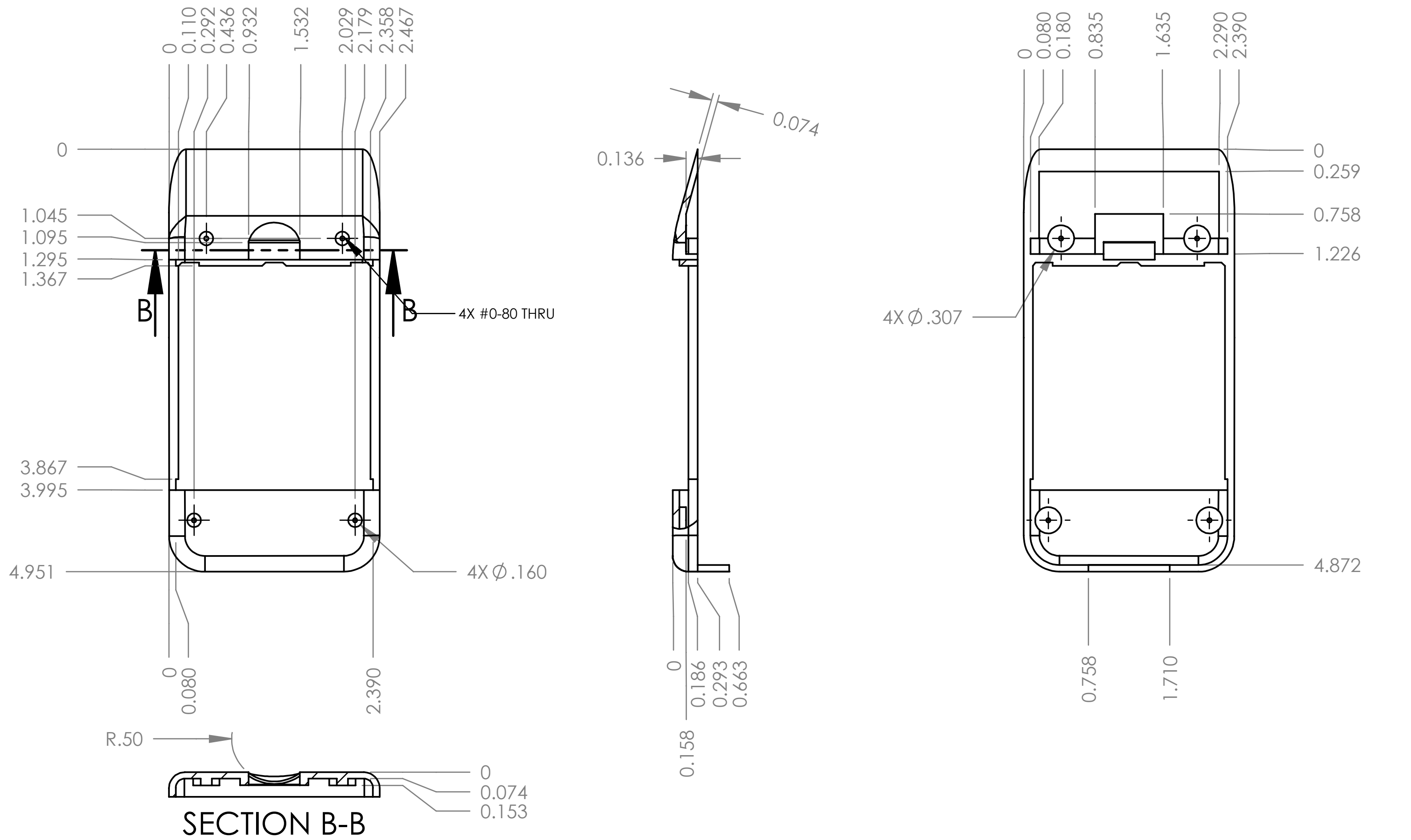
SECTION A-A





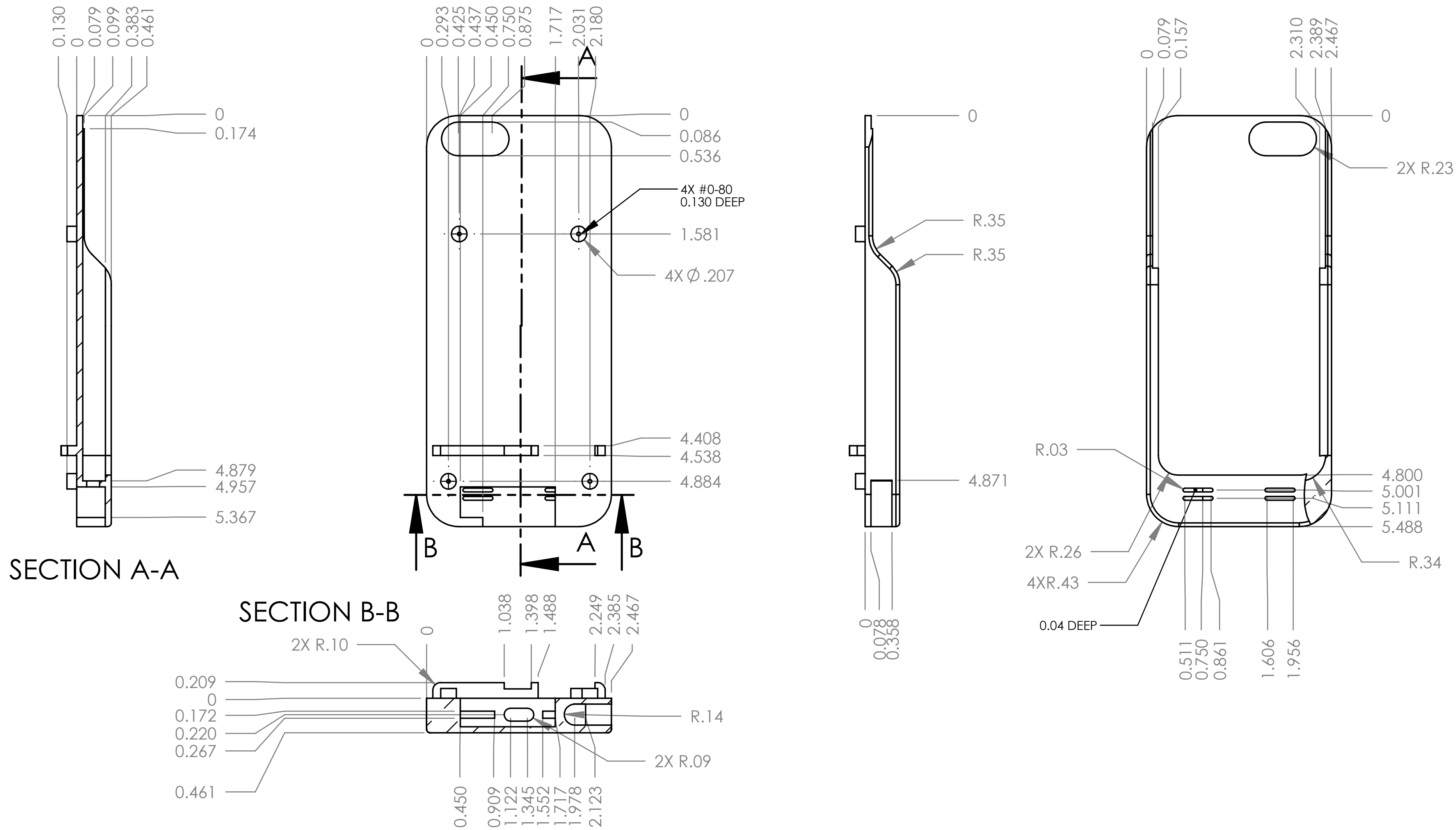
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GO JUICE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ±0.01 THREE PLACE DECIMAL ±0.005	DRAWN	JC	3.19.14	TITLE: iphone case bottom
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A — DWG. NO. — REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:1 — WEIGHT: — SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GO JUICE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ±0.01 THREE PLACE DECIMAL ±0.005	DRAWN	JC	3.19.14	TITLE:
	CHECKED			battery cover
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A — DWG. NO. — REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:2 — WEIGHT: — SHEET 1 OF 1

5 4 3 2 1

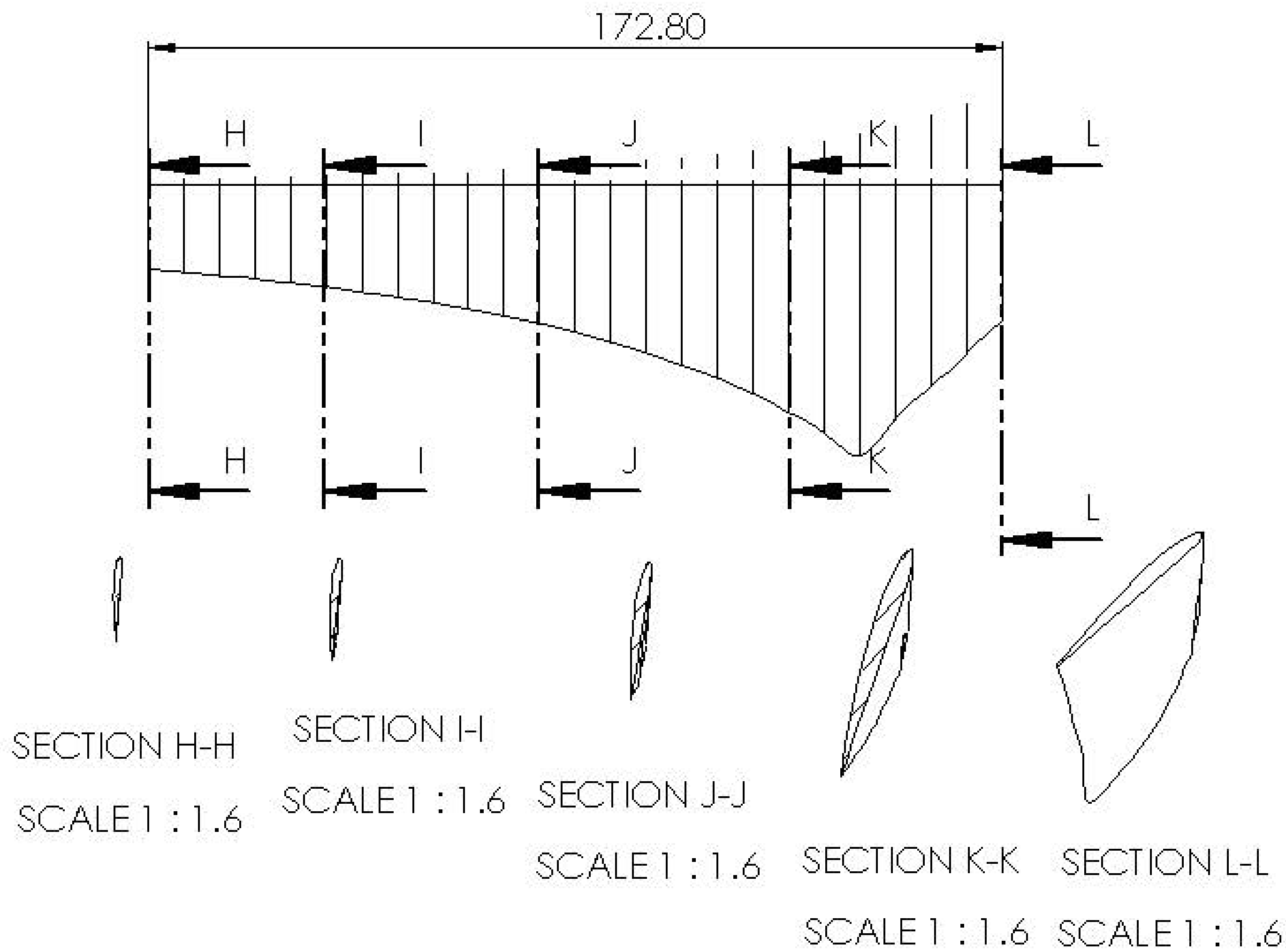


UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GO JUICE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ±0.01 THREE PLACE DECIMAL ±0.005	DRAWN	JC	3.19.14	TITLE: iphone case top
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A | DWG. NO. | REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

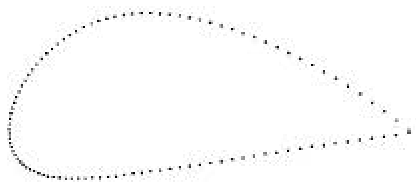
5 4 3 2 1

Appendix F: Specifications for the Wind Tunnel Test Turbine

Attached are the Specifications for the Wind Tunnel Test Turbine.



	Gamma	Cord Length
1 (L)	42.63	4.00
2	51.35	4.36
3	58.00	4.79
4	63.09	5.30
5	67.07	5.92
6	70.22	5.30
7 (K)	72.79	4.79
8	74.89	4.36
9	76.65	4.00
10	78.14	3.69
11	79.41	3.43
12	80.51	3.19
13	81.47	2.99
14 (J)	82.32	2.81
15	83.07	2.65
16	83.74	2.51
17	84.34	2.38
18	84.88	2.26
19	85.37	2.16
20 (I)	85.81	2.06
21	86.23	1.97
22	86.60	1.89
23	86.95	1.82
24	87.27	1.75
25 (H)	87.57	1.68



Naca 2408 Profile

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN CENTIMETERS
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	ES	4/13/14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

GoJuice

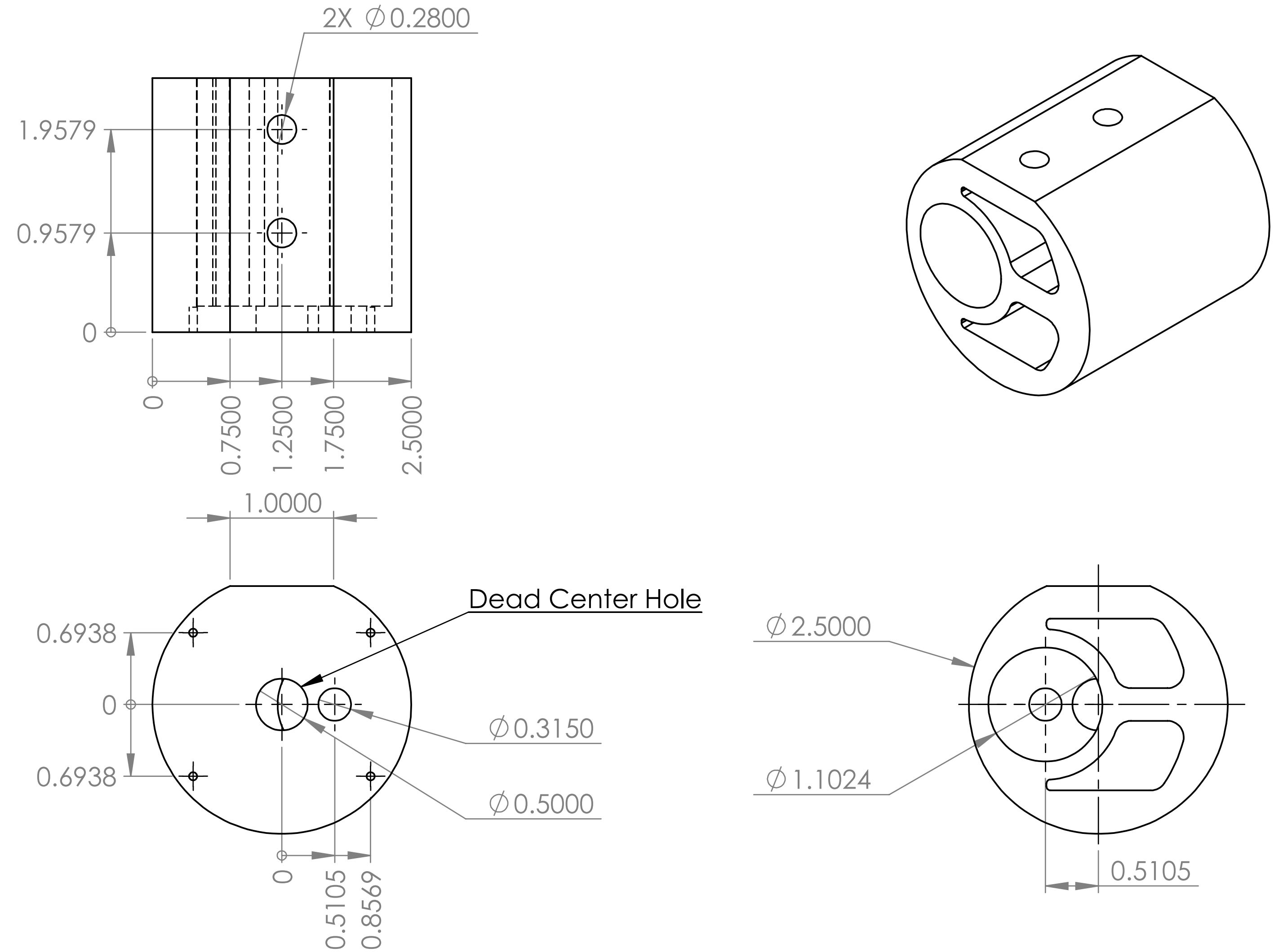
TITLE:

NACA 2408

SIZE A | DWG. NO. 1 | REV 2

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



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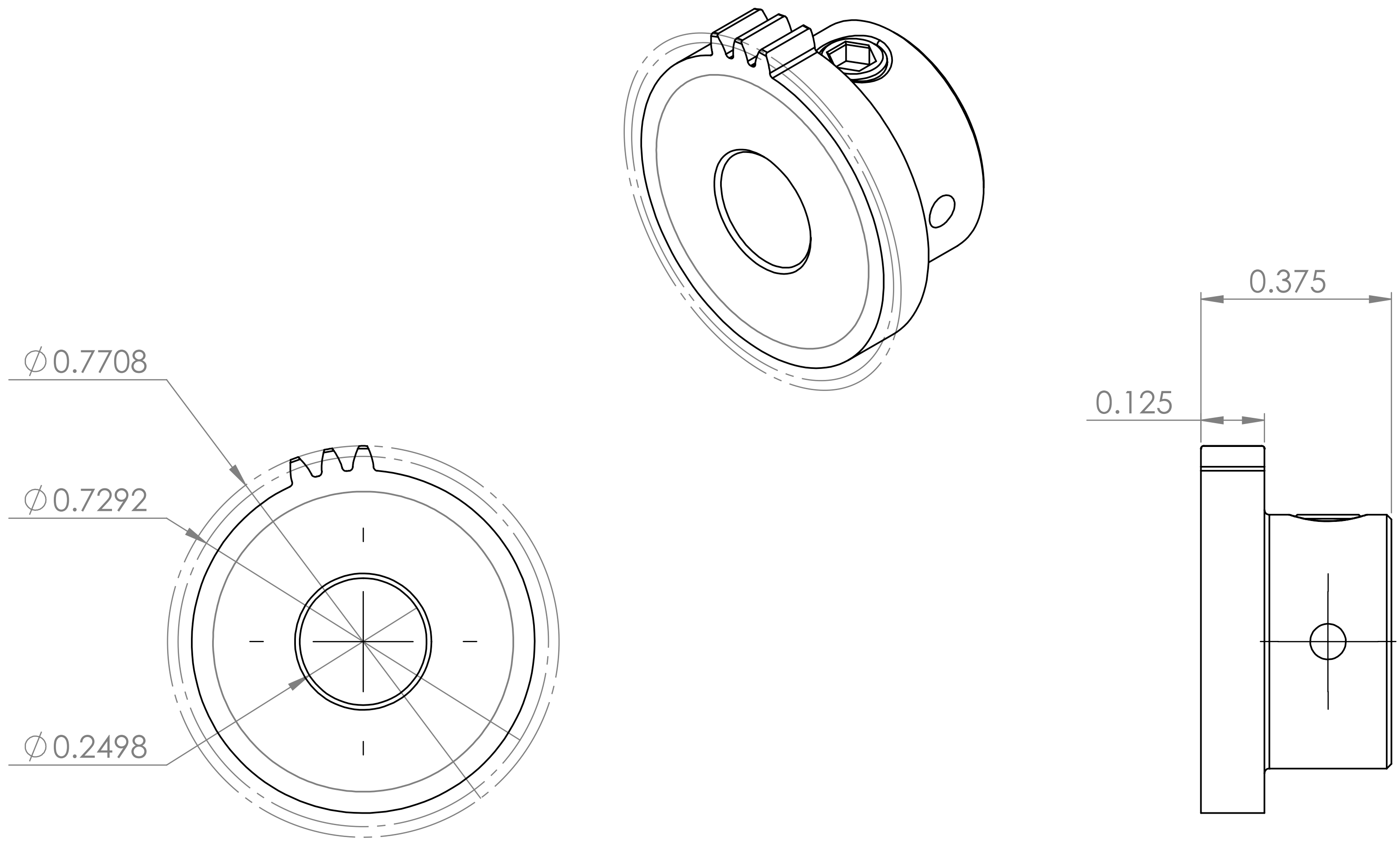
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	M. Dube	4/18/14	TITLE:
	CHECKED			
	ENG APPR.			Motor Housing
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL ABS Plastic/ Aluminum	COMMENTS:			SIZE A · DWG. NO. Motor_Housing · REV 1
FINISH DO NOT SCALE DRAWING				SCALE: 3:5 · WEIGHT: · SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
STAINLESS STEEL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	M. DUBE	4/18/14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

GOJUICE

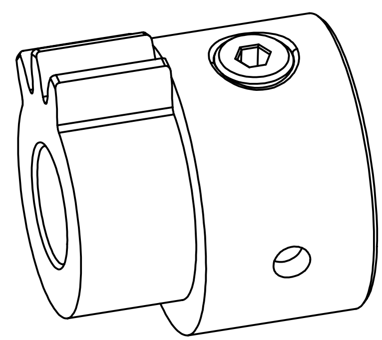
TITLE:

PINION GEAR

SIZE A | DWG. NO. PINION_GEAR | REV

SCALE: 3:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



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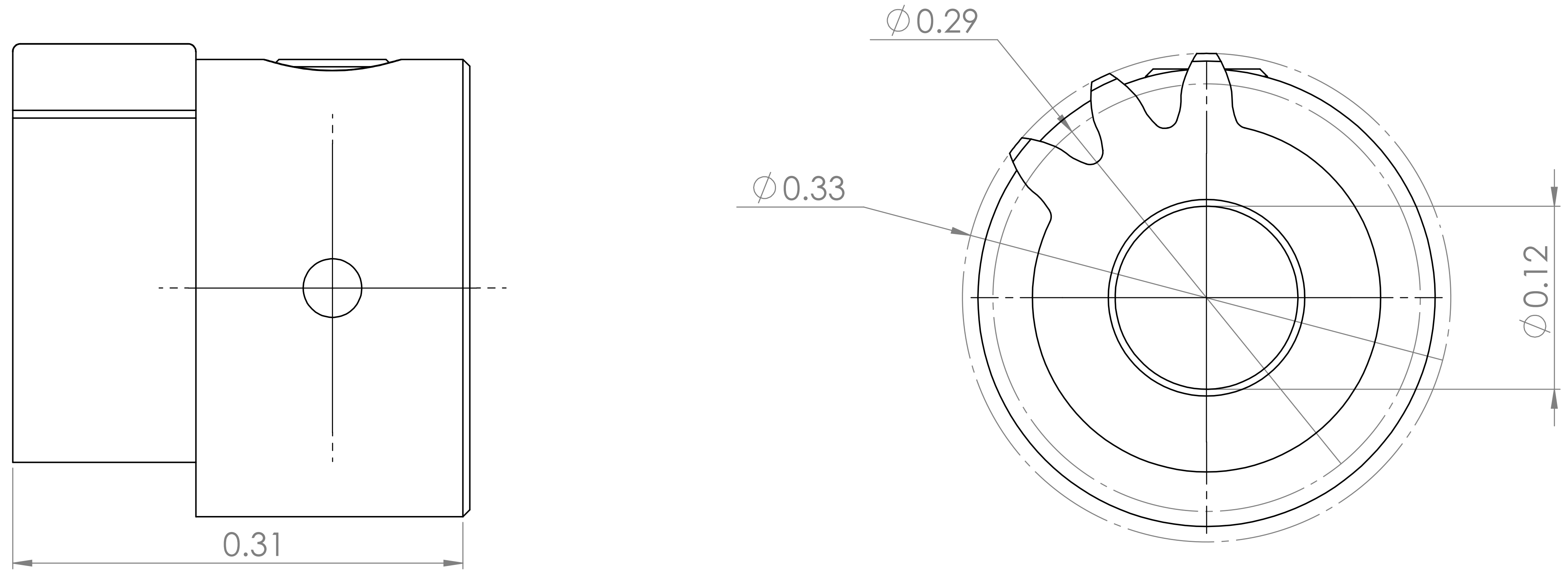
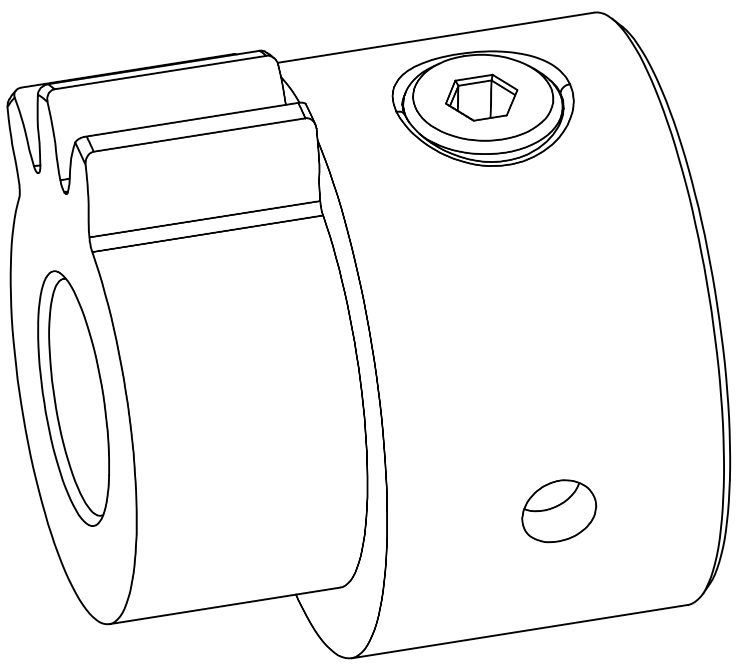
	CHECKED			Spur Gear
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL Stainless Steel	COMMENTS:			SIZE A / DWG. NO. / REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 5:1 / WEIGHT: / SHEET 1 OF 1

5 3 2 1





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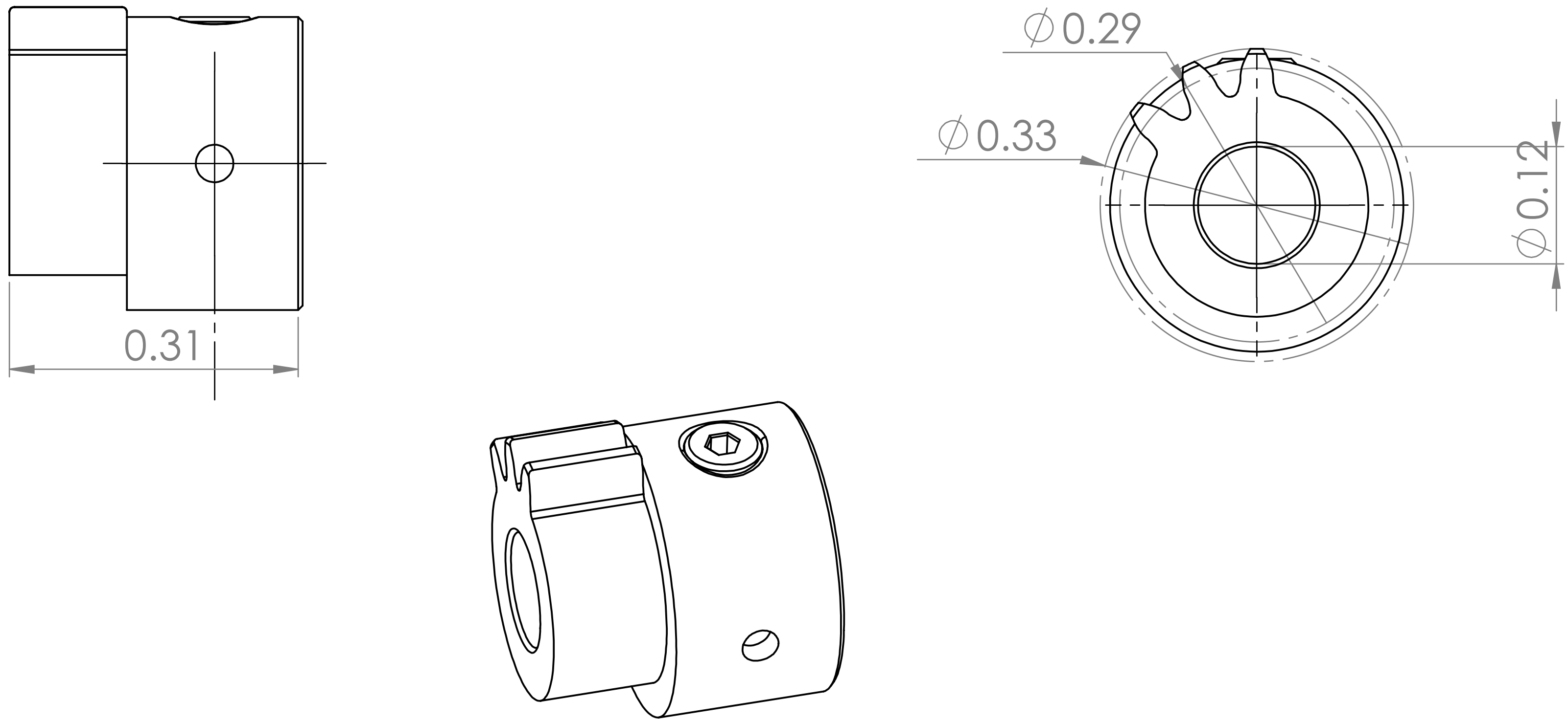
	NAME	SIGNATURE	DATE				TITLE:	
DRAWN	Erika Sjoberg		4/18/2014				GoJuice	
CHK'D								
APPV'D								
MFG								
Q.A				MATERIAL: Stainless Steal			DWG NO. Spur Gear	A3
				WEIGHT:			SCALE:10:1	SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GOJUICE
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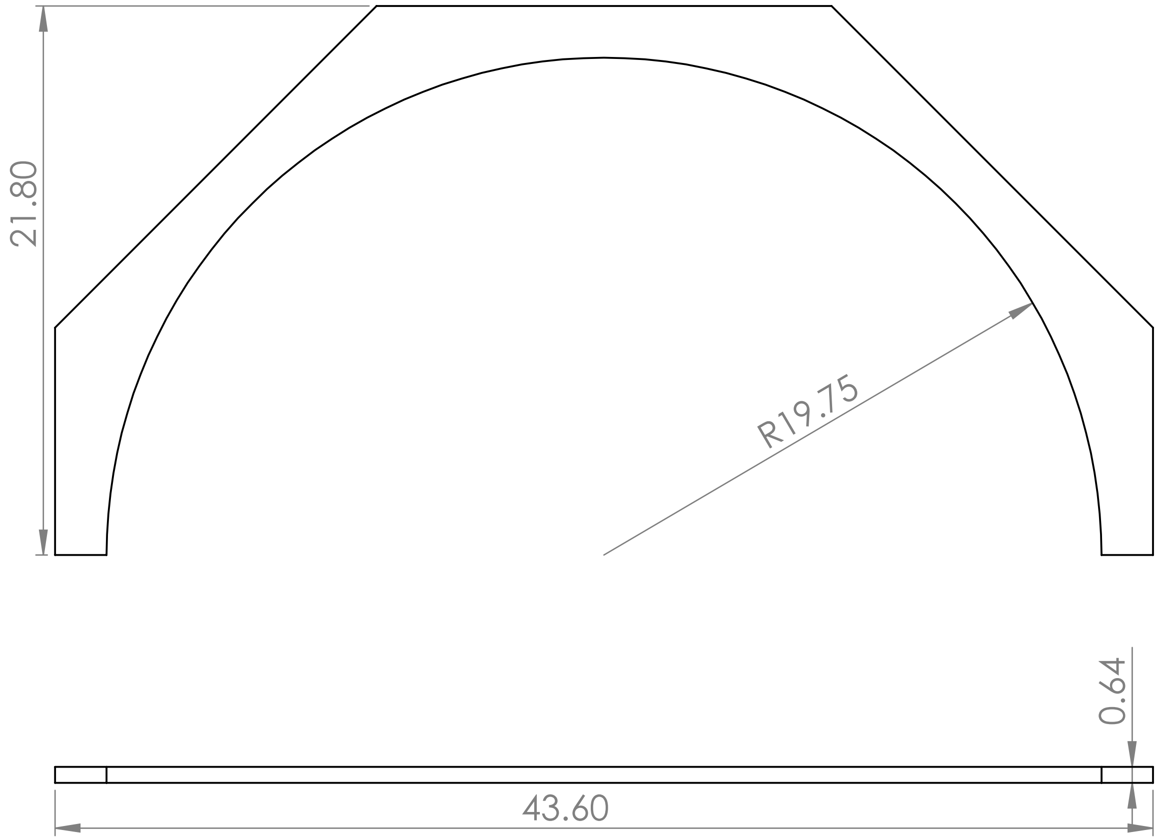
	CHECKED			Spur Gear
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL Stainless Steel	COMMENTS:			SIZE A · DWG. NO. · REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 5:1 · WEIGHT: · SHEET 1 OF 1

5 3 2 1



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN mm
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MKS	4/18/14
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

GO JUICE

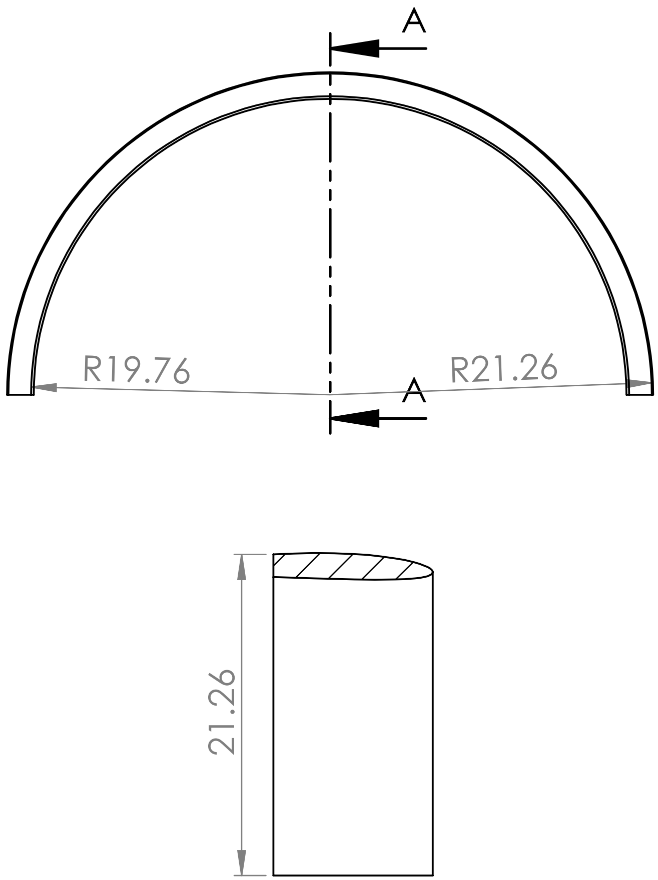
TITLE:

Diffuser Half

SIZE	DWG. NO.	REV
A	1	

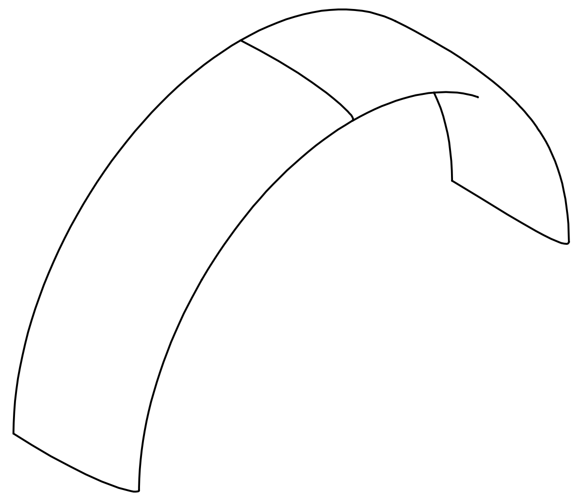
SCALE: 1:3 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



SECTION A-A

SCALE 1 : 5



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	GO JUICE
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	CHECKED			NACA 2408 - foam foil
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A — DWG. NO. 1 — REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:10 — WEIGHT: — SHEET 1 OF 1

5 4 3 2 1

U.S. Department of Energy (DOE) Collegiate Wind Competition

University of Massachusetts Lowell

GoJuice

Wind Turbine Team		
Dean Kennedy	Mechanical Engineering	Dean_Kennedy@student.uml.edu
Christopher Daly	Plastics Engineering	Christopher_Daly@student.uml.edu
Donna DiBattista	Plastics Engineering	Donna_DiBattista@student.uml.edu
Michael Dube	Mechanical Engineering	Michael_Dube@student.uml.edu
Michael Schaefer	Plastics Engineering	Michael_Schaefer@student.uml.edu
Erika Sjöberg	Mechanical Engineering	Erika_Sjoberg@student.uml.edu
Erik Anderson	Mechanical Engineering	Erik_Anderson@student.uml.edu
Battery Kiosk Team		
Parth Patel	Plastics Engineering	Parth_Patel@student.uml.edu
Peter Jones	Plastics Engineering	Peter_Jones@student.uml.edu
Meaghan Riley	Plastics Engineering	Meaghan_Riley@student.uml.edu
Adapter Case Team		
David Phung	Mechanical Engineering	David_Phung@student.uml.edu
Jeffrey Chung	Mechanical Engineering	Jeffrey_Chung@student.uml.edu
Patrick Logan	Mechanical Engineering	Patrick_Logan@student.uml.edu
Electrical Engineering Team		
Alexandre Sampaio	Electrical Engineering	Alexandre_Sampaio@student.uml.edu
Albert Andino	Electrical Engineering	Albert_AndinoAponte@student.uml.edu
Isaac Grullon	Electrical Engineering	Isaac_Grullon@student.uml.edu
Jigar Patel	Electrical Engineering	Jigar_Patel@student.uml.edu
Graphic Designer		
Kristin Morrissey	Entrepreneurship	Kristin_Morrissey@student.uml.edu
Business Team		
Bobby LeBoeuf	Entrepreneurship	Robert_LeBeouf@student.uml.edu
Gregory Lennartz	Entrepreneurship	Gregory_Lennartz@student.uml.edu
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Design Objective

The engineering design of the GoJuice wind turbine-kiosk-phone system (Figure 1) aligns with its business objective – to provide a streamlined smartphone battery exchange experience using batteries charged by renewable energy sources. Consumers lead busy lives and demand immediate gratification, so the engineering design must account for the intermittent wind source and slow battery charge rate of mobile electronic devices. GoJuice provides a business value proposition to the consumer offered by no other competitor via a seamless engineering approach that transforms intermittent wind energy sources into immediately available power for mobile devices via GoJuice's simple and convenient battery exchange.

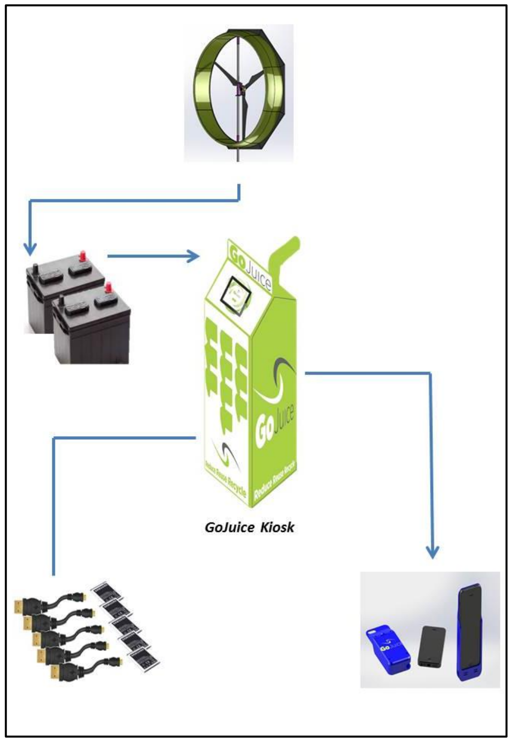


Figure 1. GoJuice System Diagram

The GoJuice system technical design responds to the economics of renewable energy, the practical limitations of wind/solar power generation for smartphones and the technological constraints of transportable solutions for charging portable electronic devices. The economics of wind energy strongly disfavor small installed system sizes due to the dramatic increase in the cost per installed capacity (Figure 2). The GoJuice team recognizes that to avoid being a niche player in the renewable energy space, the engineering design must progress toward larger capacity systems in order to minimize the cost differential with solar and other renewable energy resources. Simultaneously the turbine must be transportable between seasonal deployment locations; as such, the team has car-

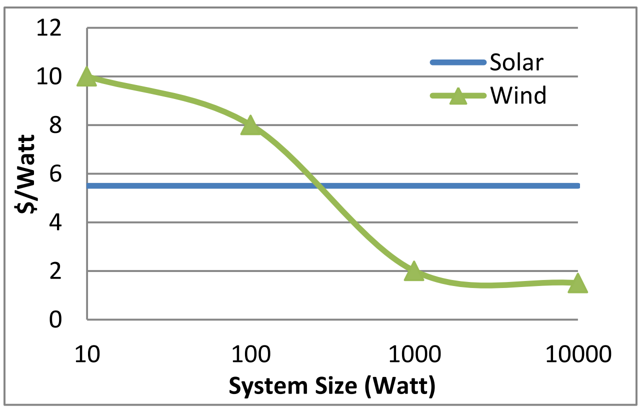


Figure 2. Energy Cost per Watt

ried prototype systems and found that an installed rotor diameter of 2.5 meters balances the needs of economics with transportability.

In light of the economics discussed above, several generic GoJuice Kiosk deployment sites were considered (Figure 3). Here, we focus on applications with wind resources. Popular outdoor locations, such as ski slopes, beaches, or open parks offer ready access to fully wind or wind-solar hybrid deployments. In order to meet the estimated 150 user interactions per day, a fully wind-powered 2.5 meter diameter system requires 5.5 m/s average wind speed assuming a Weibull distribution.

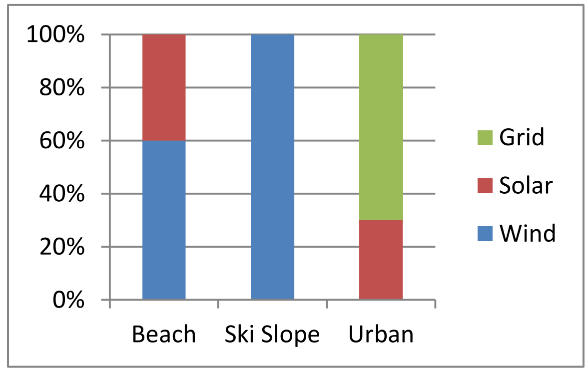


Figure 3. Energy Source by Site

Design Team

Figure 4. Organizational Chart

System Design Overview

The unique design features include: (1) an efficient and non-intrusive energy transfer via a one-minute auxiliary battery exchange (2) an efficient shrouded downwind turbine and direct drive Permanent Magnet Generator (PMG) system that exploits the benefits of larger-scale wind generation and (3) a cost-competitive wind/solar, community based smartphone charging strategy that exploits the beneficial economies of community and scale.

Wind Turbine Technical Documentation

The wind turbine engineering design is described in three sections: (1) Full-Scale turbine, (2) Wind Lens Diffuser, and (3) Validation (i.e., competition) Scale Turbine.

Full-Scale Turbine

Design and Analysis

Design Objective: The purpose of the wind turbine is to generate the power required by the kiosk for auxiliary battery charging and kiosk functions while being easy to transport, install and maintain. To meet this goal, the turbine should (1) be efficient, lightweight and transportable (2) passively align with the wind (3) operate safely in high traffic areas and (4) exploit efficiency augmenting wind lens research.

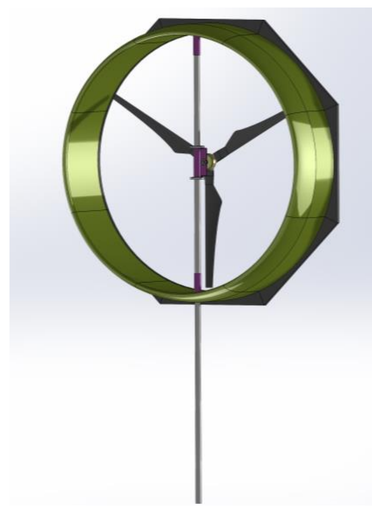


Figure 5. Full Scale Turbine Design

Design Overview: The GoJuice wind turbine is a three-bladed, downwind, shrouded rotor design (Figure 5)**.** An efficient blade design was determined using in-house, ideal Betz-analysis and Blade Element Momentum Theory computer software*.* A relatively large tip speed ratio (TSR = 6.0) and low solidity (Solidity = 0.11) was selected to achieve higher coefficient of performance and reach the rotational velocities required by direct-drive permanent magnet generators. To ensure safety at high wind speeds, electromagnetic braking is applied. The overall wind turbine system specifications are listed in Table 1.

Table 1. Wind Turbine Specifications

Rated Capacity	1.5 kW @ 11 m/s
Rotor Diameter	2.5 m (8.2 ft)
Swept Area	4.91 m^2 (52.81 ft^2)
Type	Downwind shrouded rotor
Direction of Rotation	Clockwise looking upwind
Blades	(3) Fiberglass reinforced composite
Rated Speed	500 RPM
Maximum Tip Speed	66 m/s (178 mph)
Alternator	Permanent magnet generator
Yaw Control	Passive
Max Wind Design Speed Axial Loading	1500 N @ 60 m/s (135 mph)
Braking System	Electromagnetic braking from generator
Cut-in Wind Speed	3 m/s (6.7 mph)*
Rated Wind Speed	11 m/s (24.6 mph)
Survival Wind Speed	60 m/s (135 mph)

Modeling and Testing: Several candidate blade airfoils were considered during the design process. Lift and drag coefficients were found for each using XFOIL [Drela]. From this the angle of attack corresponding to a maximum lift-to-drag ratio was determined (Figure 6).

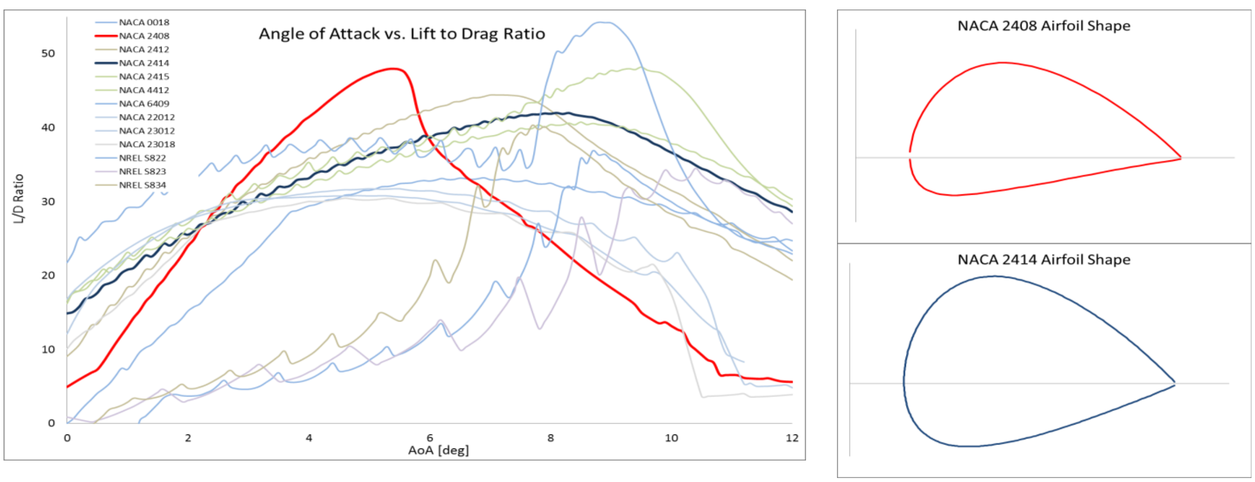


Figure 6. Angle of Attack vs. Lift Drag Ration for Various Airfoils

The lift and drag coefficient as a function of angle of attack were calculated using XFOIL [Drela] and imported into a Betz-optimal blade approximation from which the span-wise blade chord and twist were determined. Next an in-house Blade Element Momentum Theory Code (BEMT) was used to compare the coefficient of performance for different designs at the design wind speed (Table 2).

Table 2. Theoretical Coefficient of Performance for various airfoils

Airfoil	0006	0018	2408	2414	2415	22012	23012	23018	S822	6409
Optimal AoA	Not conv.	7	5.3	8.3	8.5	5.9	5.5	6.1	9.8	3.7
Cp	Not conv.	32.14	36.35	36.12	35.74	29.11	29.98	31.13	32.53	34.02

A NACA 2414 airfoil was selected due to its high coefficient of performance, its structurally advantageous thickness and its moderate stall behavior. A turbine rotor diameter of 2.5 meters will deliver the required 1,565 W-h to the kiosk at a mean wind speed of 5 m/s (11mph). The turbine has a target rated power of 1,560 W at a wind speed of 11 m/s. The desired cut-out speed is 20 m/s (45 mph) and the turbine blades are designed to withstand maximum sustained winds of up to 60 m/s (135mph). Between the cut-in and cut-out wind speeds, the blades were analyzed using the BEMT code (Reynolds number: Re = 421500 and tip speed ratio: TSR = 6). Above the cut-out speed, turbine blade loads were approximated using an equivalent arrangement of flat plates perpendicular to the flow. The maximum axial load is 1,500 N at 60 m/s (135 mph). The predicted axial load and power generation as a function of wind speed are shown in Figure 7.

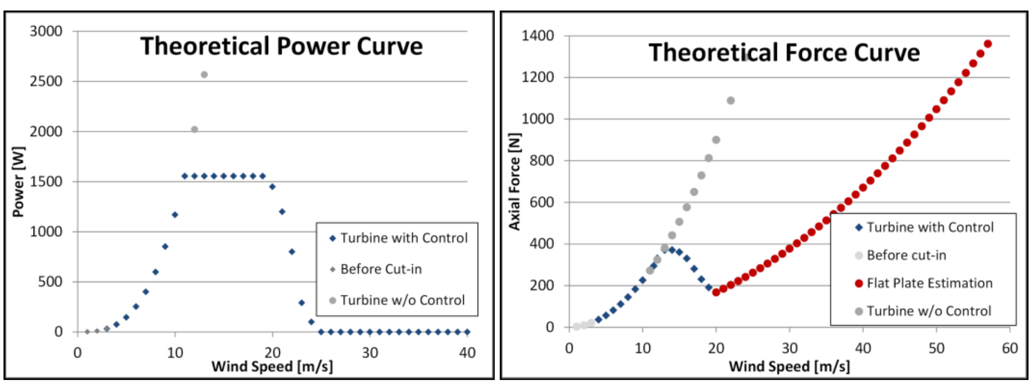


Figure 7. BEMT Results for Power and Axial Load at Varying Wind Speeds

Careful siting is critical to the success of wind turbine installations. The time required for a functional kiosk to recharge 150 auxiliary batteries as a function of time is shown in Figure 8. A wind-only solution should only be considered when daily power-average wind speeds of 5 m/s (11.2 mph) and greater are available; however, a hybrid wind-solar strategy should be considered at sites with lower average wind speeds.

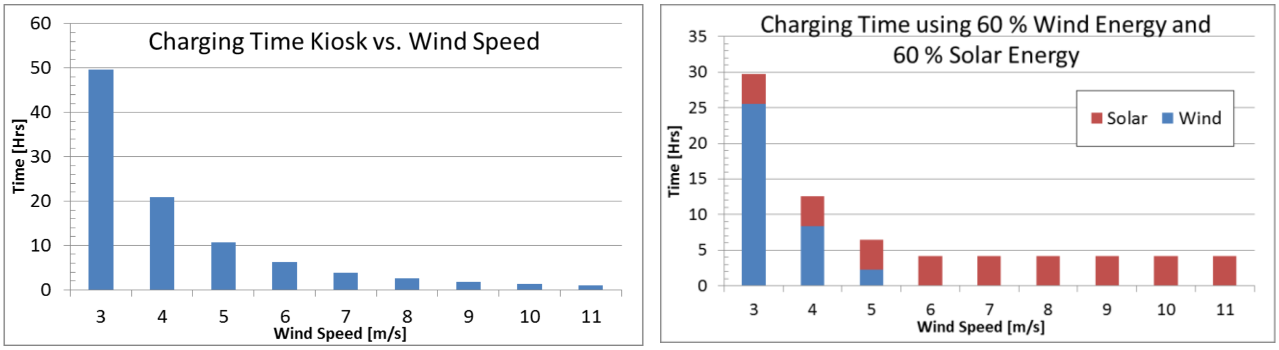
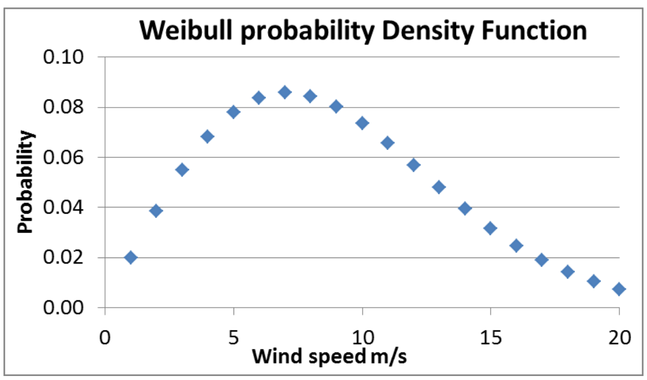


Figure 8. Time Dependence of Wind Speed for Charging the GoJuice Kiosk

A modular 250 W solar panel can be attached to the turbine, reducing charging times significantly in areas with a lower power-average wind speeds ranging from 4-5 m/s. The times calculated in Figure 8 can be reduced when looking at the Weibull distribution of wind speed. When a Weibull distribution (Shape Factor= 2) is employed, these power average velocities are increased and should be considered in the selection of kiosk sites with wind turbines (Figure 9).



Average wind u	Weibull average wind u	Power output Wind	Power output Weibull	% Difference
3.10	3.85	35.89	68.55	0.48
4.87	6.05	139.27	265.99	0.48
7.09	8.80	428.59	818.53	0.48
8.86	11.00	837.10	1598.71	0.48
10.19	12.64	1273.10	2431.43	0.48

Figure 9. Weibull Probability Distribution of Wind Speed.

Turbine Blade Manufacturing: To minimize weight and improve blade-to-blade consistency, the full scale turbine blades are manufactured from molded fiberglass. The pressure and suction sides of the blade were fabricated separately using two female molds. A desktop CNC machine with a ¼" ball mill was used to machine the blade molds from blocks of machineable Urethane foam (Ultra Machinable Prototyping foam, McMaster-Carr).

Two layers of black pigmented gel coat were applied to the mold surfaces to create a hardened, smooth and impermeable

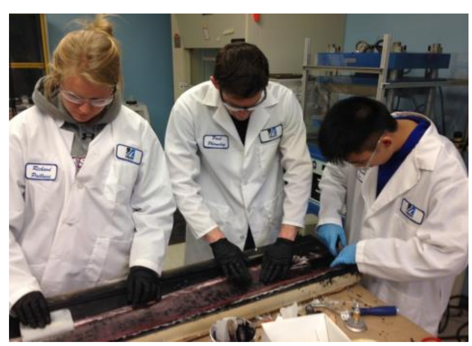


Figure 10. Release Film Application

surface. Prior to the fiberglass layup, a layer of mold release wax and Polyvinyl Alcohol (PVA) was applied to prevent the epoxy from adhering to the molds. An epoxy resin (2000, Fiberglass) was mixed with a cure hardener (2060, Fiberglass) and a 5 percent black epoxy pigment (43 Black Polyester, Fiberglass). Once mixed, a thin layer of resin was spread over the blade mold surface and four sheets of fiberglass fabric were layered onto the mold (Figure 10). The pressure side of the blade was reinforced using sheets of 3/32” balsa core. A layer of a perforated release film and a breather fabric was layered on top of the blades and vacuum bagged to compact the composite and to remove the excess resin. (Figure 11)

Figure 11. Blade Assembly

The blade was cured at ambient temperature, after which the bagging was removed from the blade halves and the blades were removed from the mold. A dremel tool with a diamond-reinforced cutting wheel was used to cut along the edges of the blade. To reinforce the root as well as attach the blades to the hub, a 3.75” by 0.75” piece of oak was glued to the root of each blade section.

Hub and Tower Assembly

Objective: The wind turbine hub and tower provide the critical connection between the wind turbine and the ground. This assembly must enable passive wind-alignment and be able to withstand the maximum wind loads from the turbine and shroud. Finally, the system should be lightweight and easy to install. Overview: A 4.0 meter tower structure supported by four guy-wires was designed to position the wind turbine for improved wind power extraction and maintain a ground clearance of just under 3 meters. A tower structural analysis has been performed to ensure the lightweight tower can sustain the maximum design wind loading. Modeling and Testing: A minimum tower height of 4.0 meters was selected to provide sufficient clearance for the average human male (1.8 meters). To maintain a cost effective design, standard steel tubing was considered. Considering this tower height, a beam bending analysis was performed to determine the basic tower dimensions. For wind speeds up to 15 m/s, a minimum of 48.3 mm OD and 3 mm thickness is required for the steel pipe. This was determined by modeling the turbine blade as a thin disk perpendicular to wind flow and calculating the drag force as shown in Figure 12. A maximum bending stress of 209.6 MPa is expected 1.25 m below the mounting position of the turbine. It is at this location where 4 steel guy wires with a 4.8 mm minimum diameter will attach to reduce the bending stresses in the tower (3.6 kN of tension per wire). The tower base can either be secured using a steel ground spike if the ground conditions are suitable enough or using bolts through a flange if operating over concrete. The guy-wires will be anchored outward similarly and tightened with tensioning devices. For purposes of testing, the built tower was 2.5 meters tall with an adjustable hub mount. The tower is welded to a flange and bolted to a wooden platform where the guyed wires are also attached. The entire structure is then to be weighted down. A prototype 2.0 meter tower has been constructed using galvanized scaffold tube/steel pipes for structural strength and corrosion resistance.

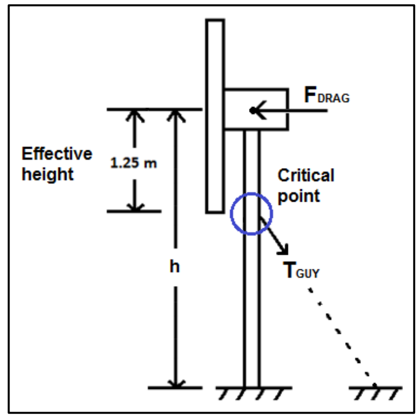


Figure 12. Support Structure

Electrical Generation and Control

Objective: The electrical power generation and control system converts the wind energy into direct current (DC) power, while maintaining safe operating conditions across a range of wind speeds.

Overview: An off-the-shelf electrical generation and control system has been specified for the full-scale wind turbine. A three phase, permanent magnet generator (currently specified as an EnergyStar 1kW generator) is used to convert the turbine mechanical enegy to AC power. An off-the-shelf emergency braking switch is installed, followed by a high current three-phase rectifier. Initially, an off-the-shelf Maximum Power Point Tracking controller will be prescribed for the product to achieve optimal wind power extraction and govern turbine operation in high winds; however, over time GoJuice will design and source a custom MPPT controller of its own.

Wind Lens

Design Objective: The purpose of the wind lens is to improve the wind turbine's power generating capability by, (1) increasing the wind kinetic energy through the rotor while maintaining reasonable wind turbine system axial loads, (2) reducing variation in wind speed, and (3) providing improved wind-alignment capability.

Design Overview: The overall design is inspired by recent research into shroud[i] and wind lens[ii] flow augmentation. An annular ring with an airfoil cross section is used to channel the flow toward the turbine rotor. A diffuser or brim portion behind the annular channel is designed to generate vortices behind the turbine rotor, which in turn create a lower pressure region behind the wind lens that augments the flow through the rotor.

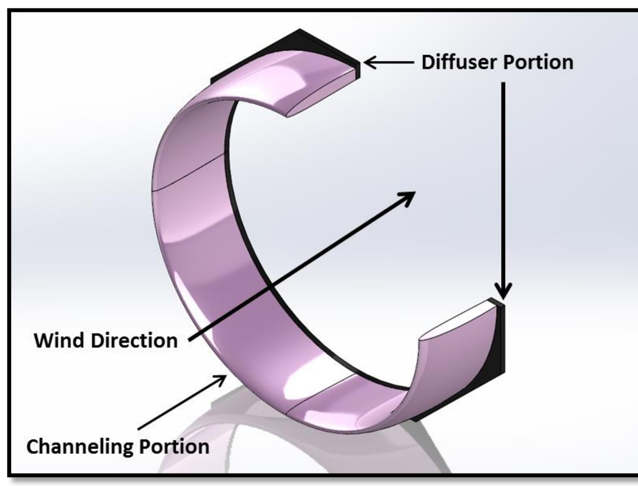


Figure 13. A Cut-Away CAD Rendering of the Wind Lens

Table 3. Velocity and Pressure Airfoil Comparison

	NACA 2408	NACA 2412	NACA 2414	Prototype 1	Prototype 2
Maximum Velocity (m/s)	20.8	20.7	20.7	20.9	20.2
% Increase in Velocity	18%	17%	17%	18%	14%
Minimum Pressure (Pa)	-39.0	-26.6	-23.2	-33.3	-54.4

Based on AutoDesk FlowDesign CFD studies, a truncated NACA 2408[iii] airfoil for the channeling section combined with an octagonal diffuser yields the optimal performance. Figure 13 is a computer aided design (CAD) rendering of the wind lens design.

Modeling and Testing: Simulations were performed comparing circular, rectangular, and octagonal shaped diffusers. An octagonal diffuser yielded the best performance increase (seen in Table 3); the rectangular design created the best flow augmentation, but unfortunately also generated prohibitively large axial forces. A comparative analysis of three airfoils was performed (Figure 14). The flow simulations were performed at 17.7 m/s, the maximum competition test speed in the wind tunnel. Table 3 exhibits the maximum velocity, minimum pressure, and percent increase values of the NACA 2408, NACA 2412, and NACA 2414 airfoils as well as the first and second prototypes. The NACA 2408 slightly outperformed the other airfoils under consideration, therefore it was selected. AutoDesk FlowDesign simulation results are shown in Figure 14.

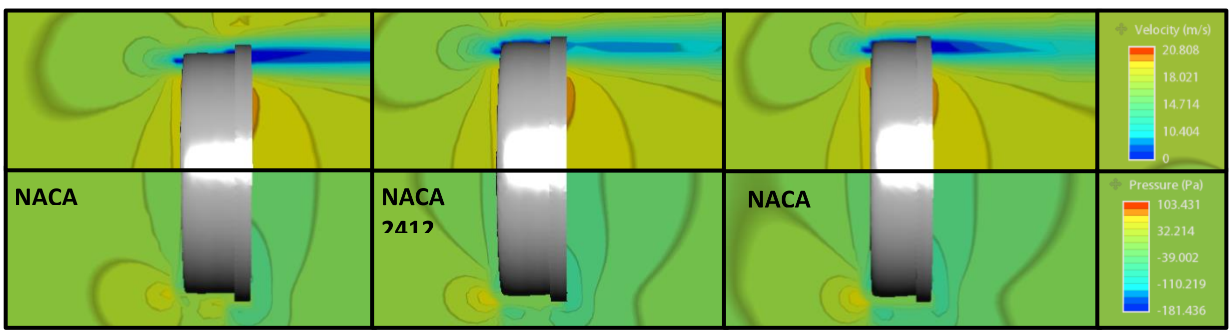


Figure 14. Airfoil Simulation Results for Velocity (Top) and Pressure (bottom)

The evidence in support of the wind lens is clear with increased power ranging from 36-47% when going from no lens to with lens at the same wind speed.

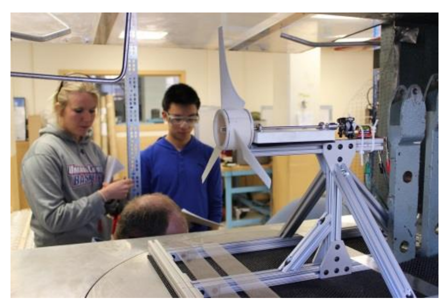


Figure 15. Prototype of Validation Turbine

Validation (Competition)-Scale Turbine

Blade Design: The test turbine blades were designed according with the sizing constraints placed by the Collegiate Wind Competition and are used to validate the design process used for the full-scale wind turbine. At this lower Reynolds number (Re ~ 80,000) and reduced turbine rotor diameter several design modifications were made, including: (1) a thinner NACA 2408 airfoil was used to compensate for the thicker boundary layer at this lower Reynolds number (2) new blade chord and twist distributions are required to maintain an optimal rotor design with a tip speed ratio of 6 (3) a gearbox was used to increase the generator rotational velocity and (4) appropriately different manufacturing techniques were adopted. These adjustments were made to allow testing and validation of the design process. The blades for the validation turbine were designed using Solidworks and 3D printed using ABS (Figure 15).

Testing and Design Validation: The objective of the testing was to verify the BEMT code outputs, measure the effectiveness of the wind lens, and to measure the optimal load at varying wind speeds. The turbine was installed in UMass Lowell's 2ft x 3ft x 4ft subsonic Wind Tunnel. For these tests, a 5-ohm rheostat was used to provide an adjustable load for turbine performance tuning. These results illustrate the importance of low electrical circuit resistance on increasing energy output efficiency.

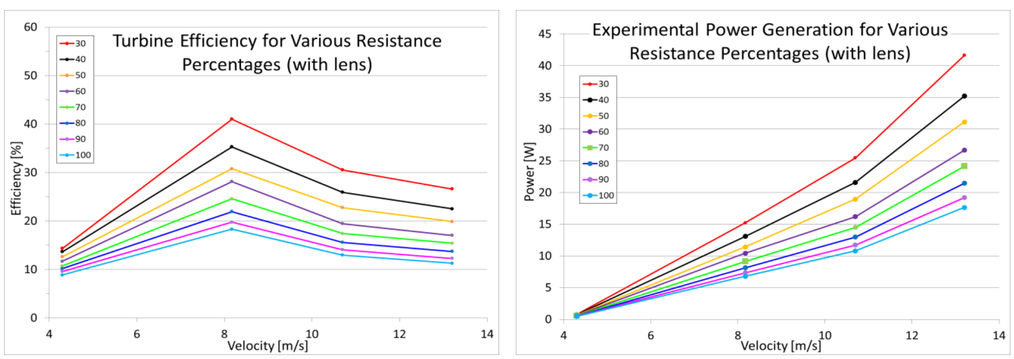


Figure 16. Effect of Wind Velocity and Electrical Resistance to Efficiency and Power

The left hand side of Figure 16 shows Efficiency vs. Velocity for the optimal velocity range of 6-10 m/s. This corresponds to an efficiency range of 27-42% with a 1.5-Ohm load and 13-18% with a 5-Ohm load. The experimental power curves exhibit a non-linear wind speed-power relationship that bears some resemblance to the expected cubic behavior. The tunnel-scale turbine power output varied from 6-23 W at 30% loading in the optimal velocity range and 4-9 W with a 5-Ohm load in the optimal velocity range.

Nacelle Design Overview: The main objective of the test nacelle design (Figure 17) was to enclose a gearing system to improve the stability of torque transfer. By providing a gear ratio of 2.5:1, the angular velocity of the generator can be improved, resulting in a larger power output. The final design is comprised of a motor housing that mounts to a rear plate which sandwiches the gear system between. The majority of the nacelle has been manufactured in 3D printed ABS material; however it was designed to be fabricated out of aluminum stock if durability or heat transfer from the motor became a concern.

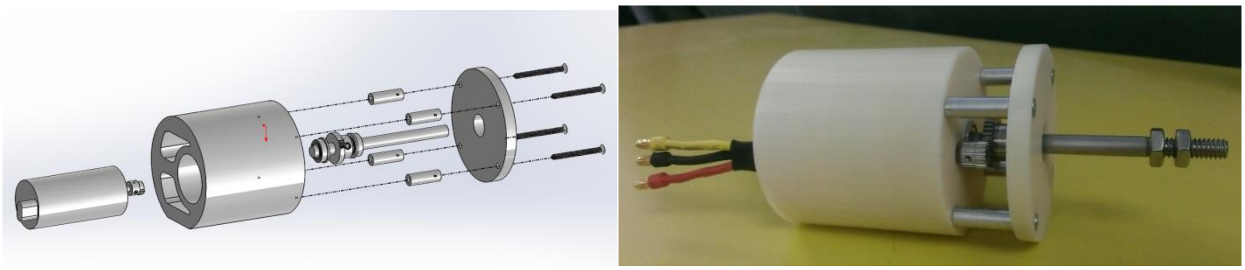


Figure 17. Exploded View and Final Prototype of Nacelle Design

Wind Lens Validation: Wind tunnel tests were performed to compare the forces on the turbine support structure. Figure 18 provides the force versus wind speed data for prototype one (a circular diffuser) and prototype two (an octagonal diffuser) (Figure 19).

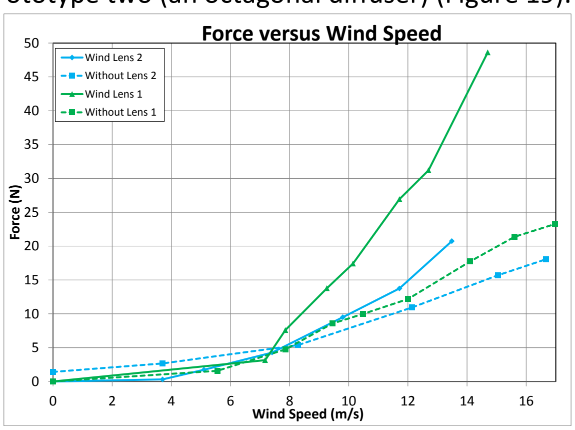


Figure 18. Force on turbine with, without wind lens.

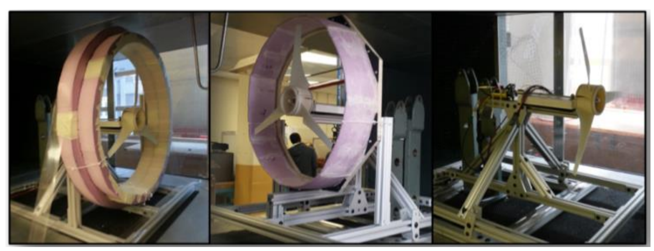


Figure 19. Prototype 1 with lens (Left), Prototype 2 with lens (Middle), Prototype with no lens (Right).

A significant force difference was observed between the two prototypes above a velocity of 7.66 m/s. After reaching this critical wind speed, the observed forces are higher with the lens than without.

Wind tunnel tests were performed evaluate the effect of the wind lens on generator rotational speed. The wind lens increases the average generator speed by a minimum of 12% across the three wind speeds. A range of wind speeds were tested for the turbine with and without the lens. The evidence in support of the wind lens is clear with increased power ranging from 36-47% when going from no lens to with lens at the same wind speed (Figure 20,21).

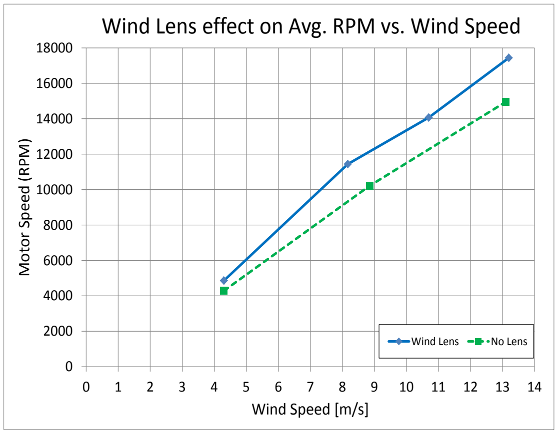


Figure 20. Effect of wind lens on avg. rpm vs. wind speed.

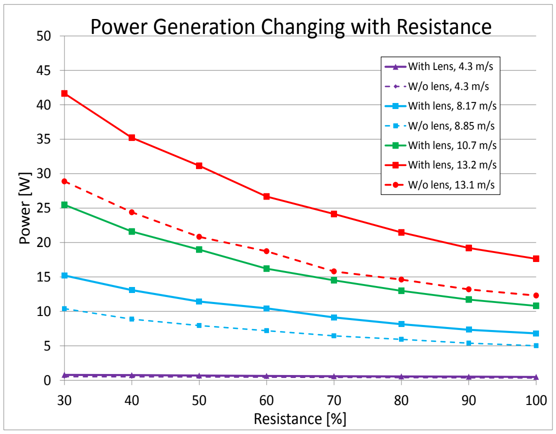


Figure 21. Power Measurements with Increasing Resistance and Wind Speed with and without Wind Lens.

Electrical Power System and Control

The prototype power system consists of a three phase rectifier bridge. Rectified power is supplied to a power conditioner module and a separate buck/boost converter. Current monitoring from the power conditioner is performed via low resistance current sensing resistor in line with power output. An operational amplifier is used to determine current flow through the sense resistor. When turbine shutdown is necessary, the controller activates a set of normally open relays, which impose a short circuit across the three phase generator output. Under normal wind conditions, the high load placed on the generator causes sufficient back-torque to stop the turbine rotor. The relays are latching and require intervention to reset, as the controller will lose power during the shutdown. Off-the-shelf parts will be used for the initial prototype design. Figure 22 shows a basic system schematic.

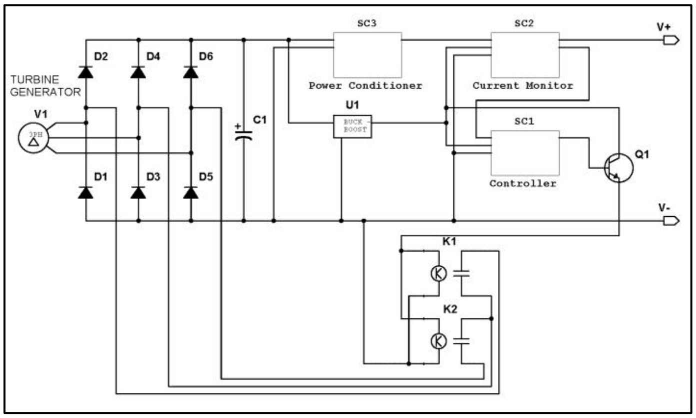


Figure 22. System power and control schematic.

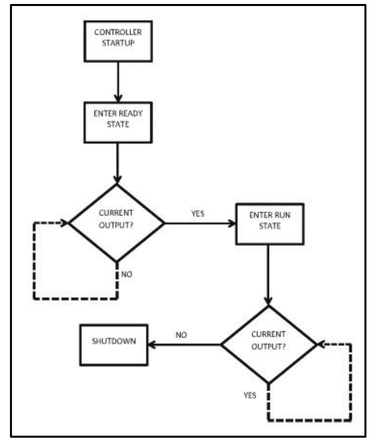


Figure 23. Basic Controller Logic

Modeling and Testing:

On startup, the turbine controller enters a ready state. In the ready state, the controller monitors current output from the power conditioner. Once current output is detected, the controller enters a run state. In the run state, the controller continues to monitor current output. When current is no longer detected, the controller shuts down the turbine by activating the shutdown relays. Figure 23 shows the basic controller logic.

Kiosk Technical Documentation

Design Objectives: The primary goals of the GoJuice kiosk are (1) to provide an effective user experience through a professionally-designed, interactive user interface; (2) to provide a nearly instantaneous auxiliary mobile phone battery exchange; (3) to protect and recharge auxiliary and station batteries both outdoors and indoors; and (4) to provide a fourth-generation internet connection between the station and GoJuice's user database/advertisement servers. A team of 3 were tasked for the concept, design, user-interface and interaction, and construction of the GoJuice kiosk.

Figure 24. GoJuice Kiosk

Engineering Specifications

Table 5 below, represents the daily energy requirement for a GoJuice Kiosk that will be powered by 100% Wind, and/or a hybrid system including solar and grid.

Table 5. Kiosk Power Consumption and Daily Energy Requirements

Mode	**Power Consumption**	**Hours/day**	**Daily Energy Requirement**
Interface Mode	200 W	2.5 h[1]	500 W-h/day
Sleep Mode	10 W	21.5 h	215 W-h/day
Charging Mode	7.5 W per battery	0.75 h x 150 charges	850 W-h/day
Total			**1,565 W-h/day**

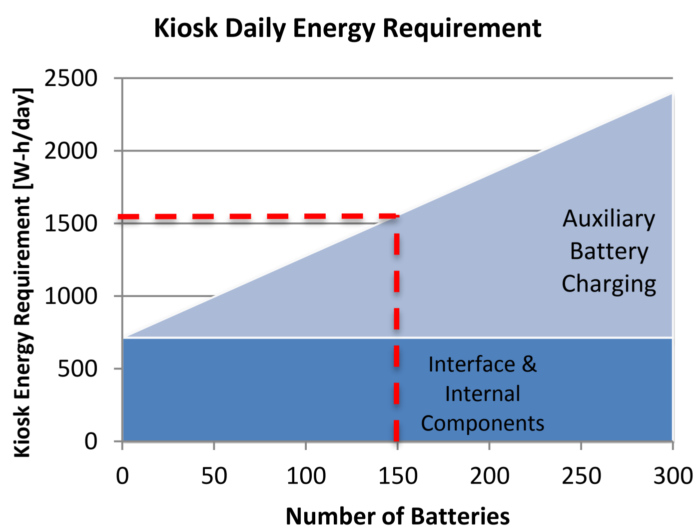


Figure 25. GoJuice Kiosk Required

The energy generated by the wind turbine and/or solar panels for off grid kiosk system will store generated energy in two deep-cycle batteries, each 12 Volt and 125 A-h. The deep-cycle batteries will provide the necessary power to charge 10 auxiliary batteries at any given time, which would be sufficient to support 150 auxiliary batteries over a 15-hour time period. These 12-Volt batteries are connected to the kiosk universal 12-V power bus. For kiosks connected to the electrical grid, there is no need for internal kiosk energy storage, and green power is exchanged with the grid through net metering; hence, AC wind power and DC solar power are transformed to 12 V-DC and directly connected to the internal kiosk power. The kiosk has two operational states: an interface mode, and a sleep mode, and a continuous charging mode. The interface mode is when the kiosk is in operation by playing an advertisement and exchanging auxiliary batteries. Sleep mode is during which the kiosk is running only the screensaver and the RFID embedded system.

During charging mode, most of the power harnessed is routed to recharge the batteries. Each station stores and manages 150 auxiliary mobile phone batteries, each 3.7 V and 1,200 mAh, which are directly recharged from the 12-V power bus. Depending on the number of battery exchanges occurring at a given kiosk, the daily energy requirement would increase incrementally by 5.625 W-h/charge, with a fixed energy cost of 715 W-h/day, as represented in Figure 25. The conversion of green power to usable energy will involve some losses. In the case of wind power, there will be losses due to the conversion to AC to DC current by a rectifier and voltage down-regulation to charge the auxiliary batteries. Losses of about 10% are typical for each conversion. This represents a 10% loss three times, or a loss factor of (1 – 0.1)3 = 0.729. This means around 73% of the power produced can be used for charging.

User Interface and Interaction: Kiosk users are first identified as they approach the station using the RFID tag embedded in the GoJuice phone case. The auxiliary battery exchange is performed efficiently (< 1 minute) with minimal user interaction. During the battery exchange, the customer views a targeted interactive advertisement streaming on the kiosk's low-power touchscreen, followed by a summary of their green energy savings (Figure 26). A detailed user experience flowchart is provided in Figure 27. The user experience is augmented by downloading the optional GoJuice phone application, which provides: (1) a synopsis of the environmental impact of phone charging behavior; (2) the locations of nearby GoJuice stations; and (3) storage of electronic coupons served by GoJuice.

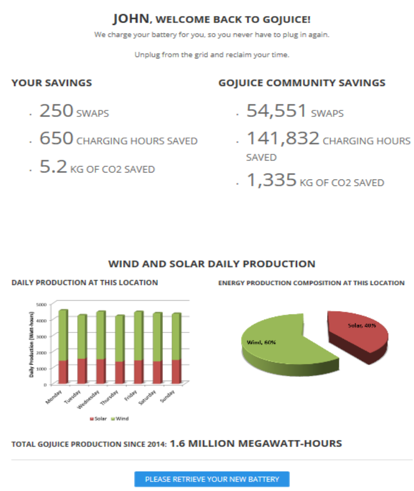


Figure 26. User Interface

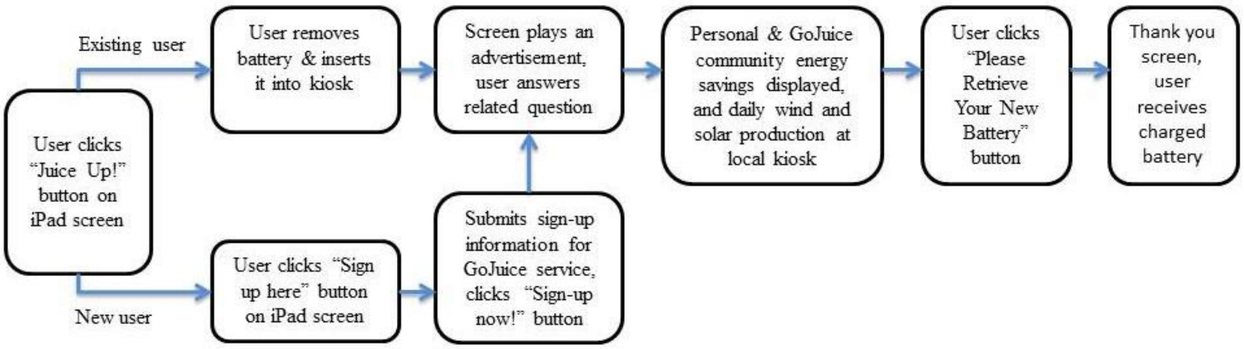


Figure 27. User Experience Flow Diagram

To provide user-interactivity, a touchscreen display, such as an iPad, will be used to handle all transactions. Internal to the kiosk, an automated robotic receiving mechanism will accept the customer's batteries and delivers them to an H-frame charging assembly (Figure 28). Subsequently, a fully charged battery is removed from the charging assembly and placed into a pick-up slot. A wireless access point will also be installed to provide network connectivity to the consumer.

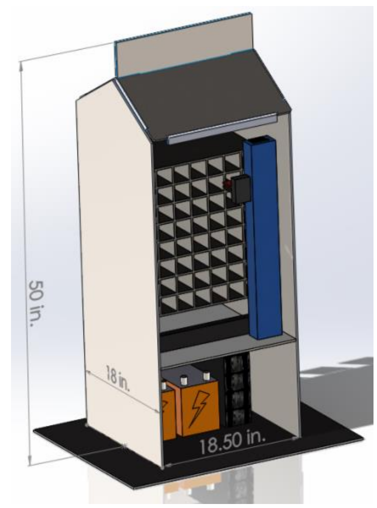


Figure 28. Kiosk Internal Structure

Figure 29 shows how the power generated by the three phase generator is sent to the rectifier, which converts AC to DC that is boosted or bucked as necessary. Then the power is transferred to a voltage controller regulator, which directly powers the display and the cell phone charging system and uses any additional power to charge the battery bank. Excess power is dissipated by a resistor bank. In hybrid systems, solar panels may provide a secondary DC power source. The system can also be integrated to the power grid to sell excess power produced rather than dumping it into a resistor bank.

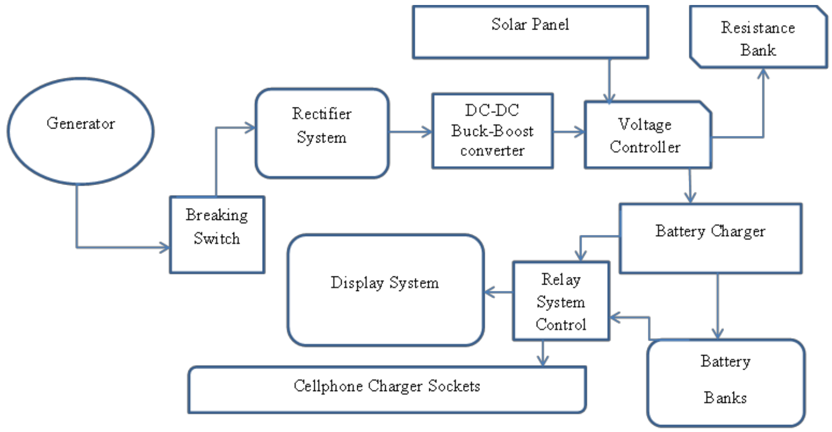


Figure 29. Electrical Block Diagram

Phone Case Technical Documentation

Design Objective: The main goal of the GoJuice phone case is to provide a seamless interaction between the GoJuice Kiosk and the user's phone while maintaining the traditional protective function of a phone case. The phone case's functionality includes: external battery storage, energy transfer by recharging the smartphone's internal battery, and providing protection and support by improving the ergonomics to better fit with the user's hands.

Design Overview: The prototype GoJuice phone case is modeled around the Apple iPhone 5 design. The case is designed for the smartphone to slide in from the top to connect with the built-in Lightning connector. A custom electronic circuit is embedded in the case to charge the phone's internal battery using the auxiliary GoJuice battery. The phone case provides space to house the external battery without hindering all OEM ports and buttons (Figure 30).

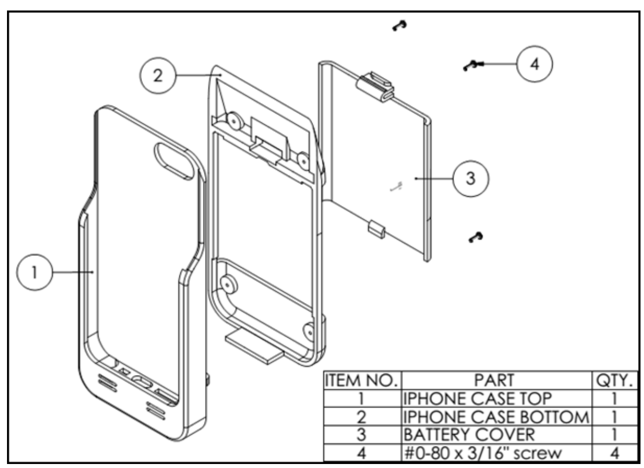


Figure 30. GoJuice Phone Case Assembly Diagram

Modeling and Testing: Having the phone slide in from the top of the case, as with this reference case, was decided to be the most appropriate method to connect the phone to the external battery. Features such as length, thickness, battery cavity size, cut-outs for OEM ports, and handling-grip were changed to better suit the needs of the user. Prototypes of the GoJuice phone case were manufactured from 3D-printed ABS plastic. An electrical circuit was created to allow for recharging of the smartphone by using the external battery. This was accomplished by satisfying two required inputs for the iPhone 5: an input 5.0 V_{DC} and an input 2.0 V_{DC} on the data terminals to communicate with the iPhone 5. A DC/DC boost converter was necessary to step-up the 3.7 V_{DC} output of the external battery to 5.0 V_{DC} while providing a maximum rated current of 600 mA. The standard Apple-issued power supply that is included with the iPhone offers a current draw of 500 mA. Major design improvements from student surveys include: making the battery cover easier to remove, additional space to house the electronics, and increased ergonomics for the user by rounding sides/corners and secure attachment of the phone and case.

Engineering Diagrams: The electrical schematic of the GoJuice phone case is shown in Figure 31.

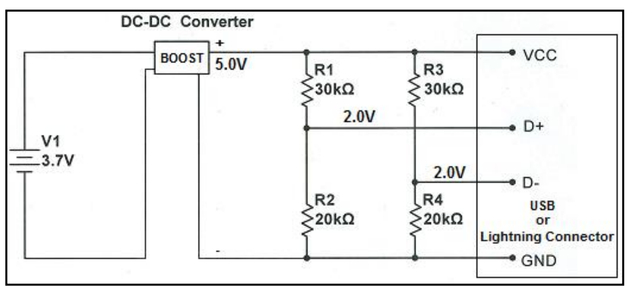
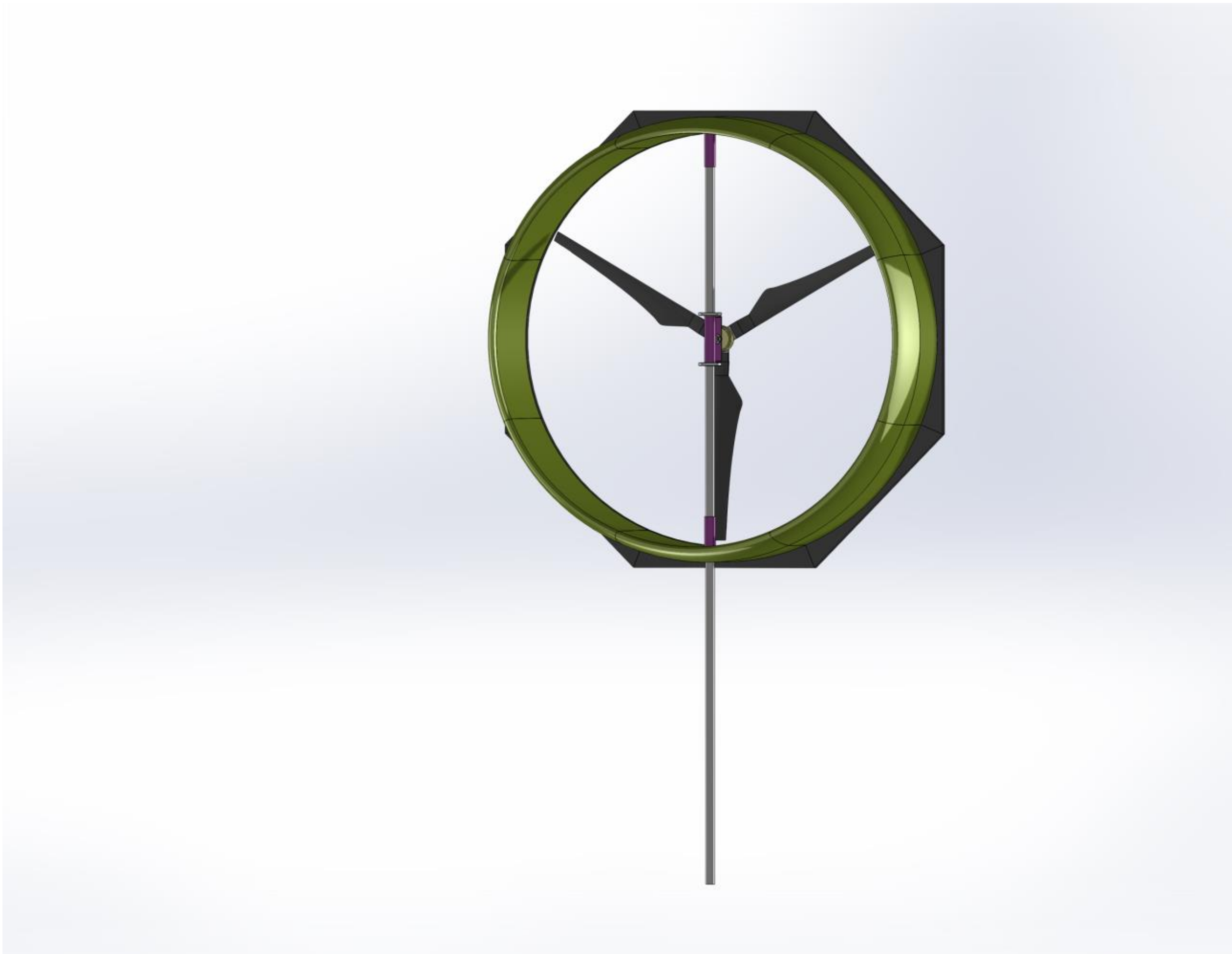
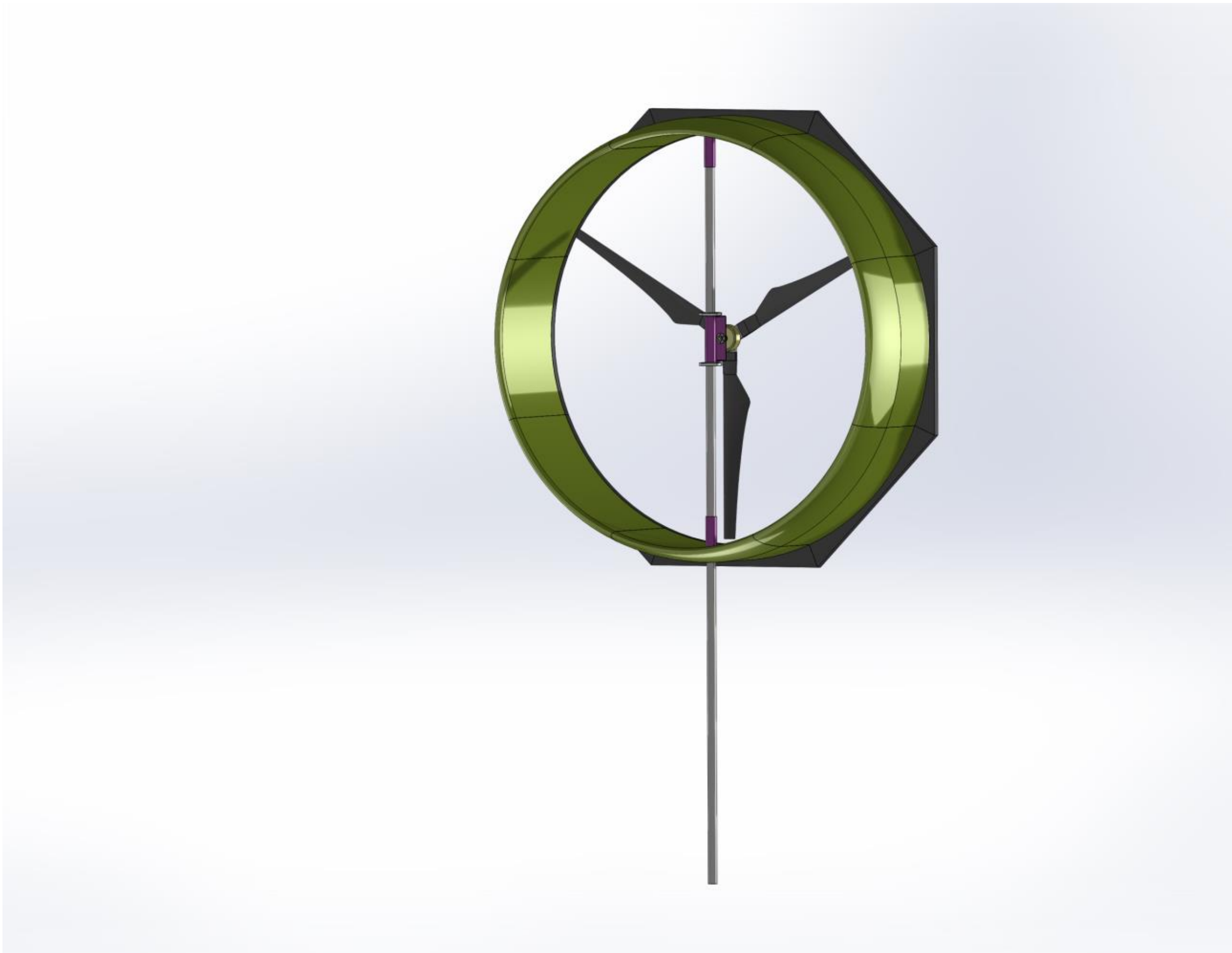
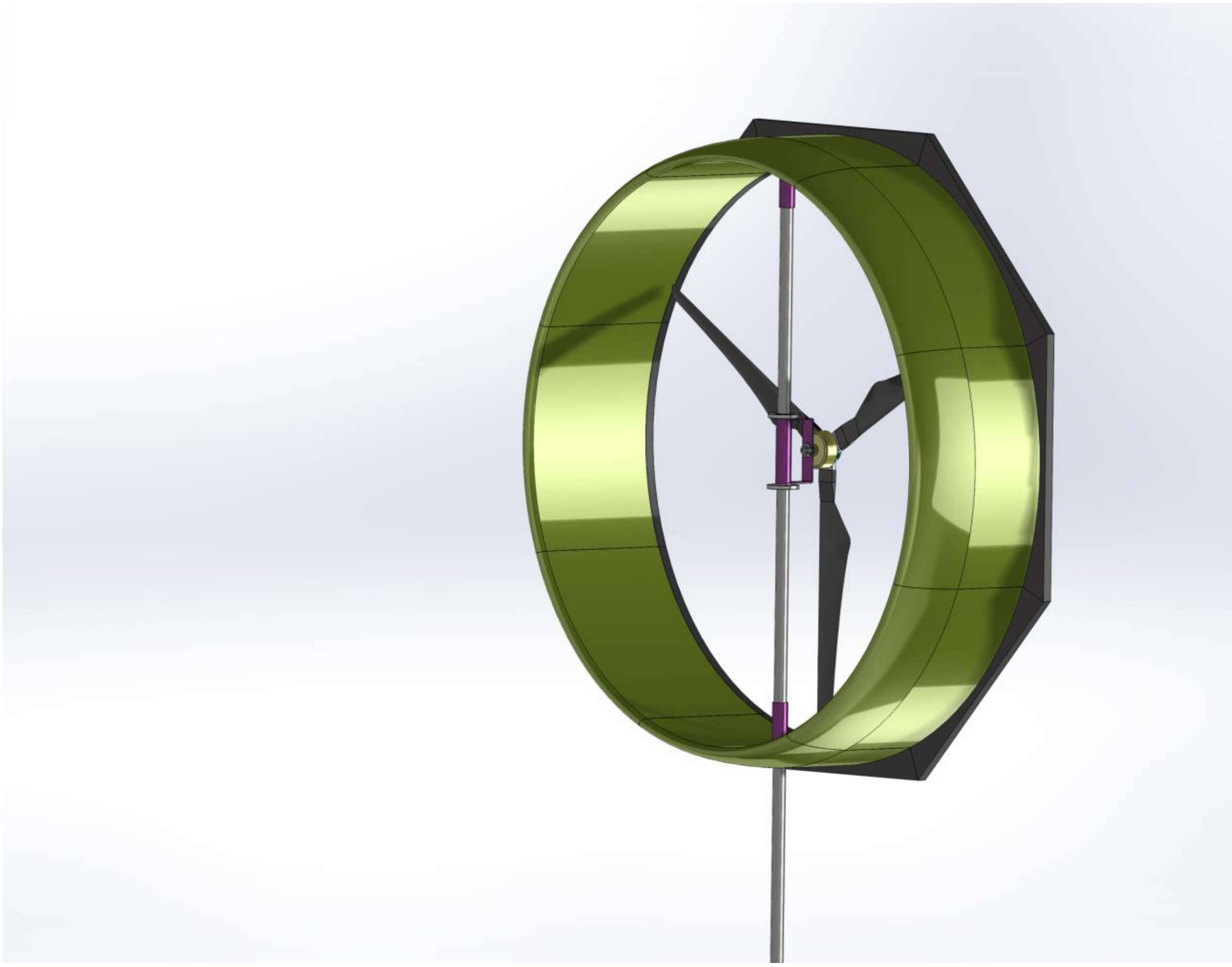


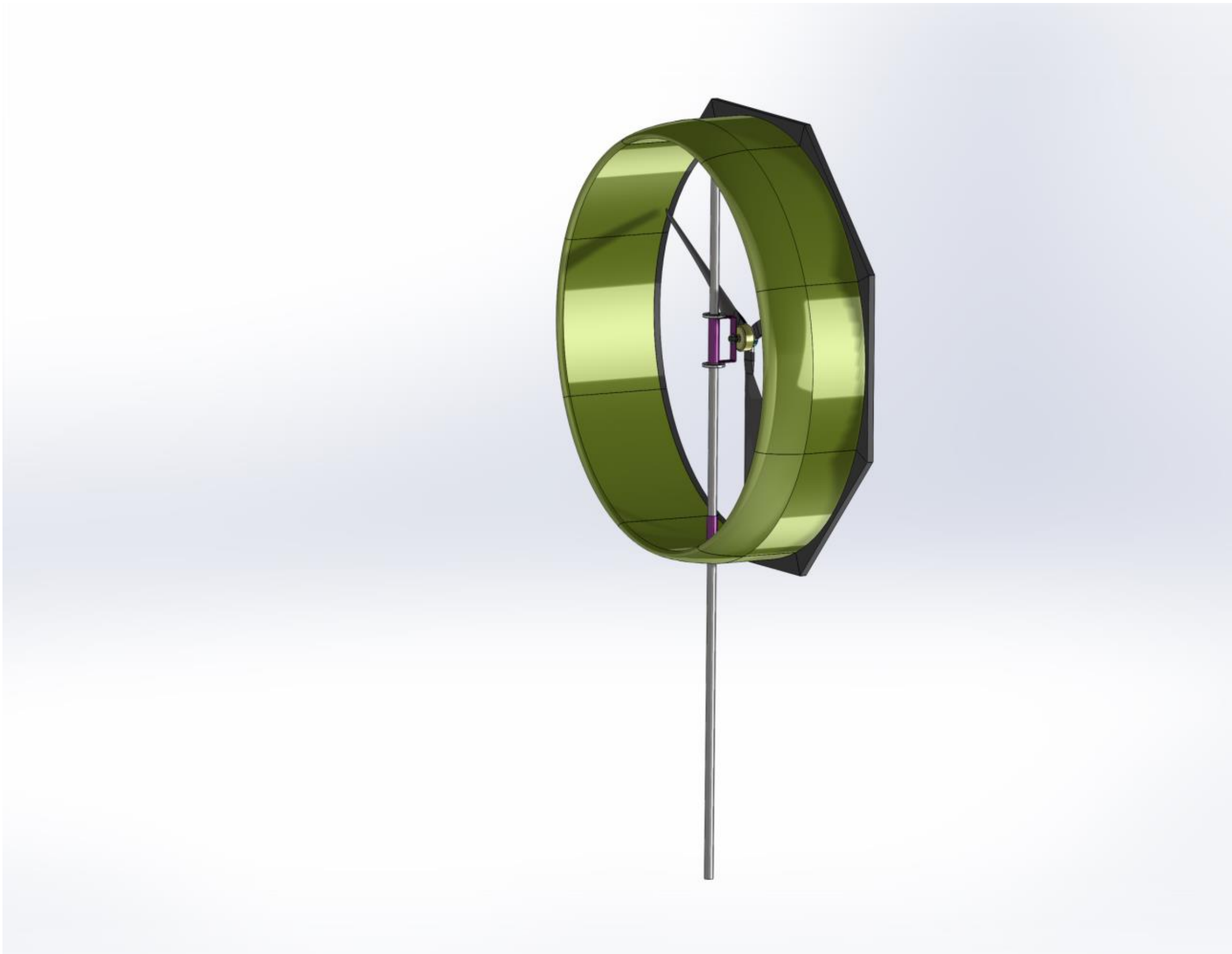
Figure 31. GoJuice Phone Case Electronics Schematic

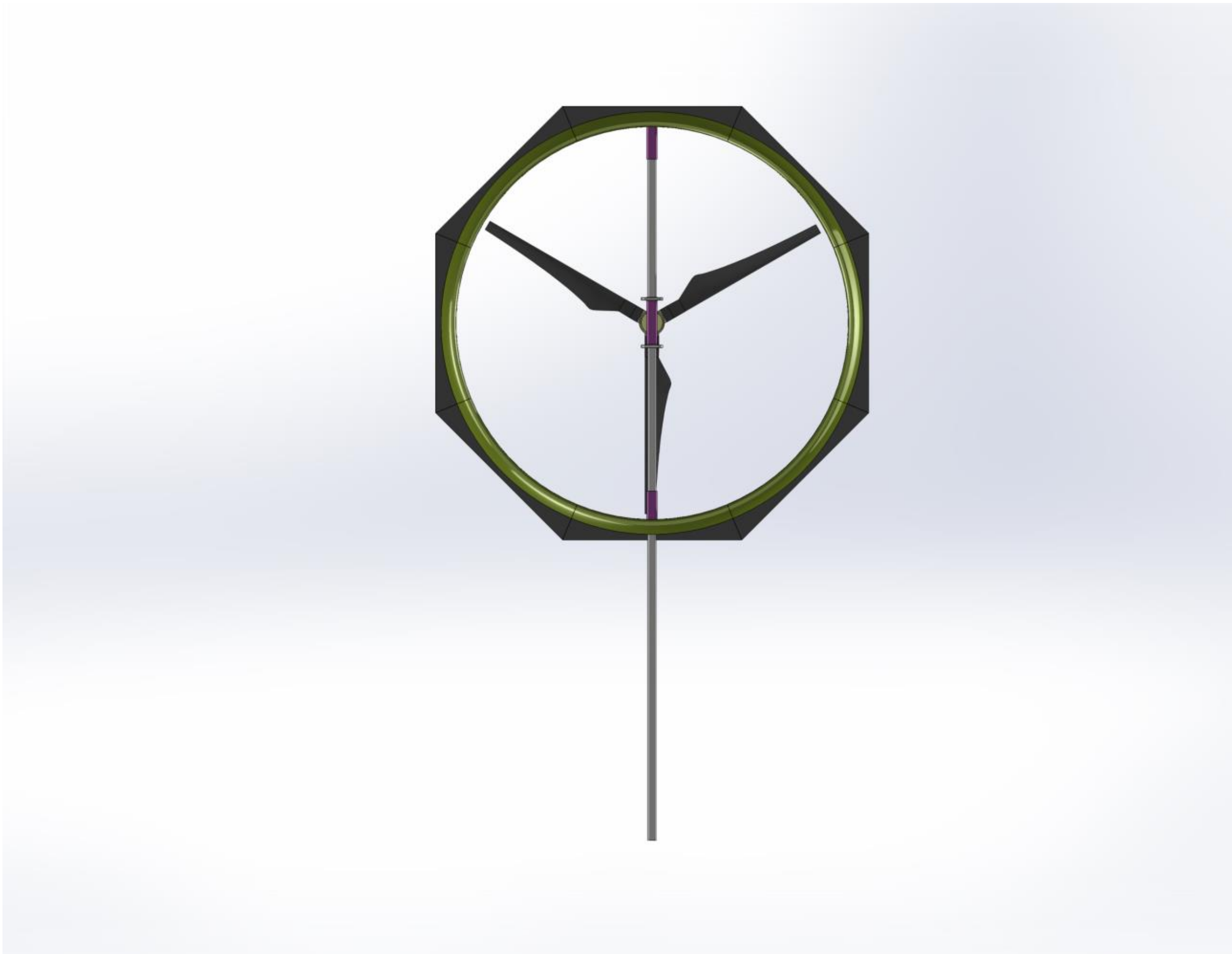
[i] Aranake, Aniket C., Vinod K. Lakshminarayan, and Karthik Duraisamy. *Computational Analysis of Shrouded Wind Turbine*. N.p., n.d. Web.
[i] "Kyushu University RIAM Wind Engineering Section Homepage - Wind Lens." *Kyushu University RIAM Wind Engineering Section Homepage - Wind Lens*. N.p., n.d. Web. 11 Apr. 2014.
[i] "NACA 2408 (naca2408-il)." *NACA 2408 (naca2408-il)*. N.p., n.d. Web. 12 Apr. 2014.

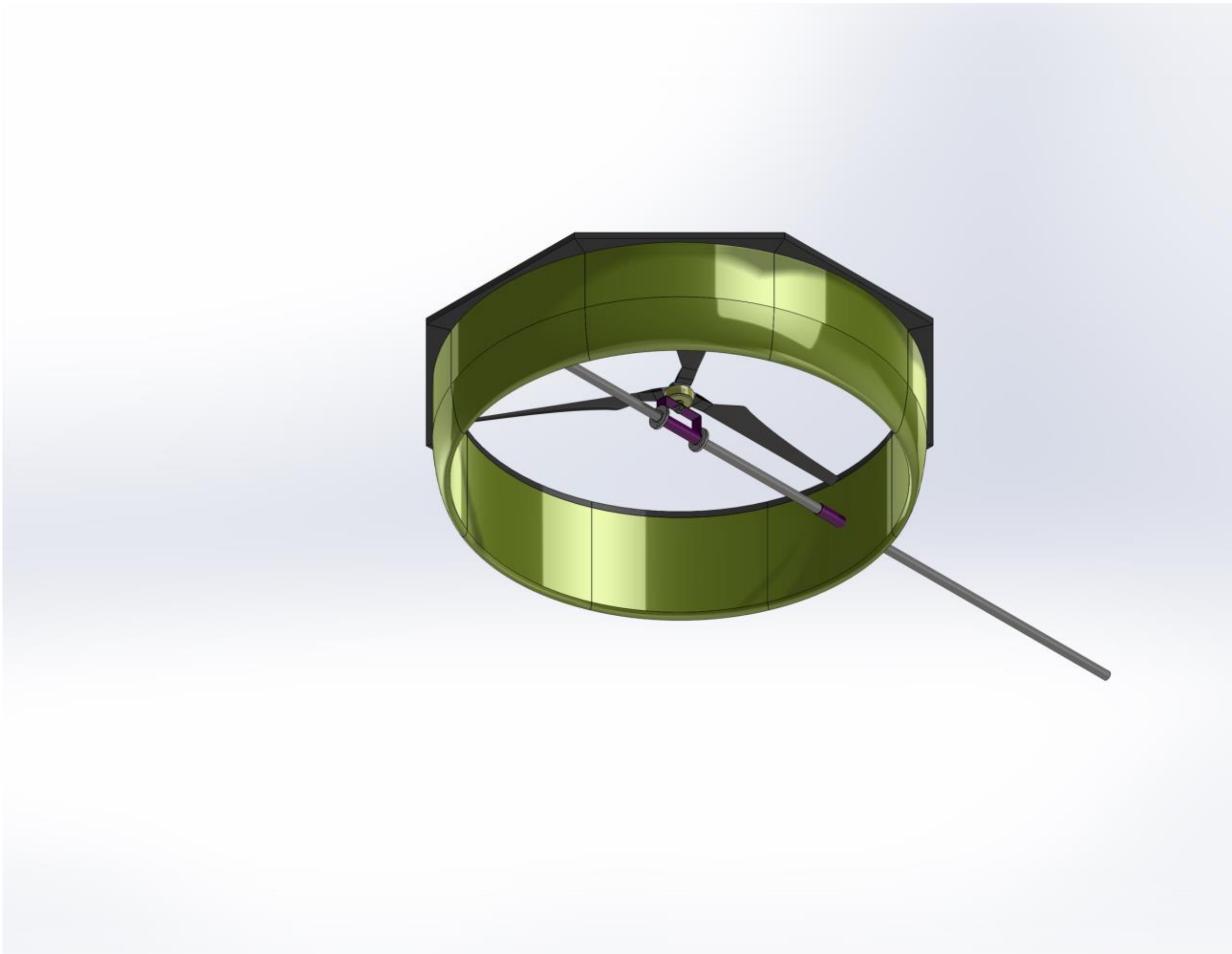


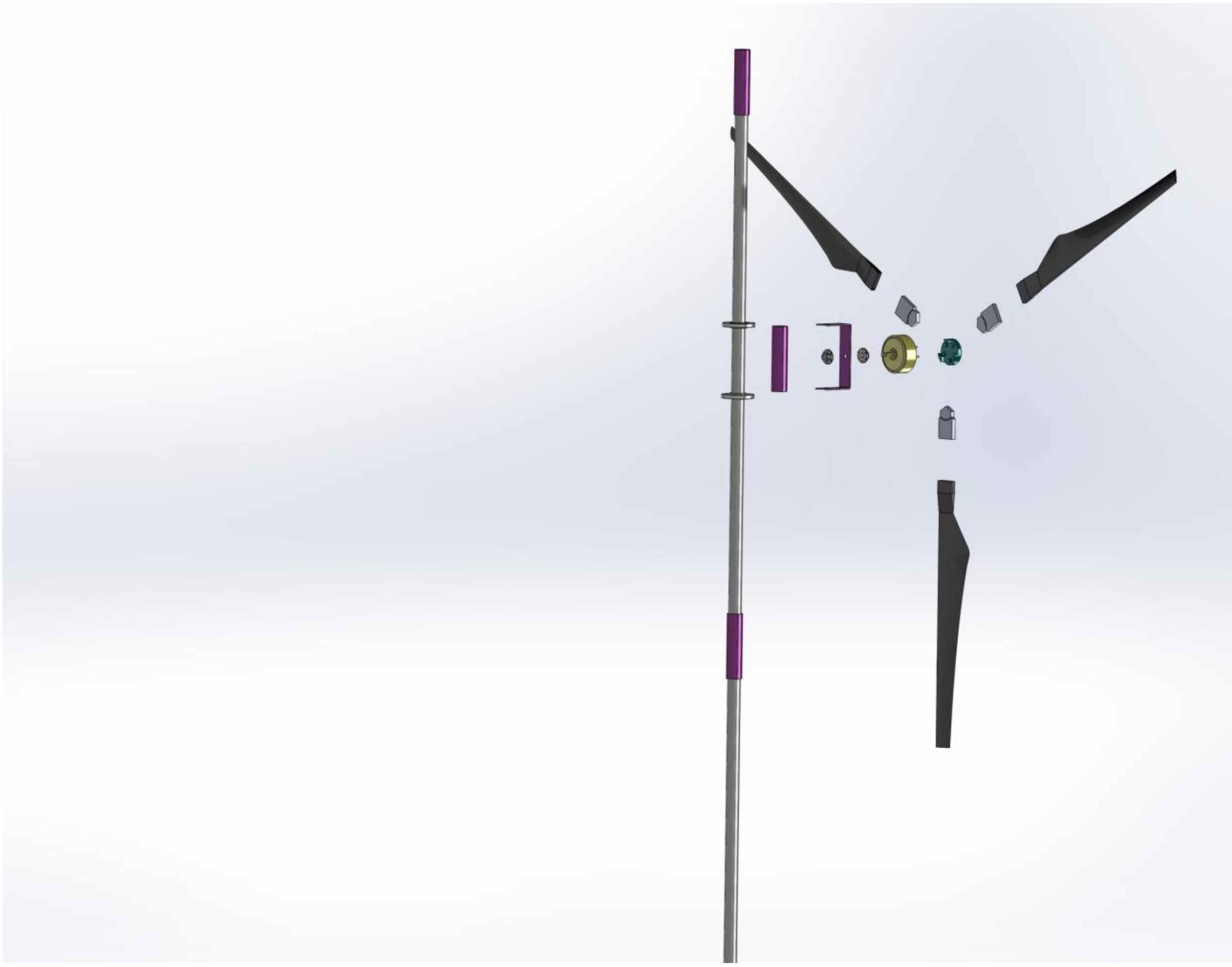


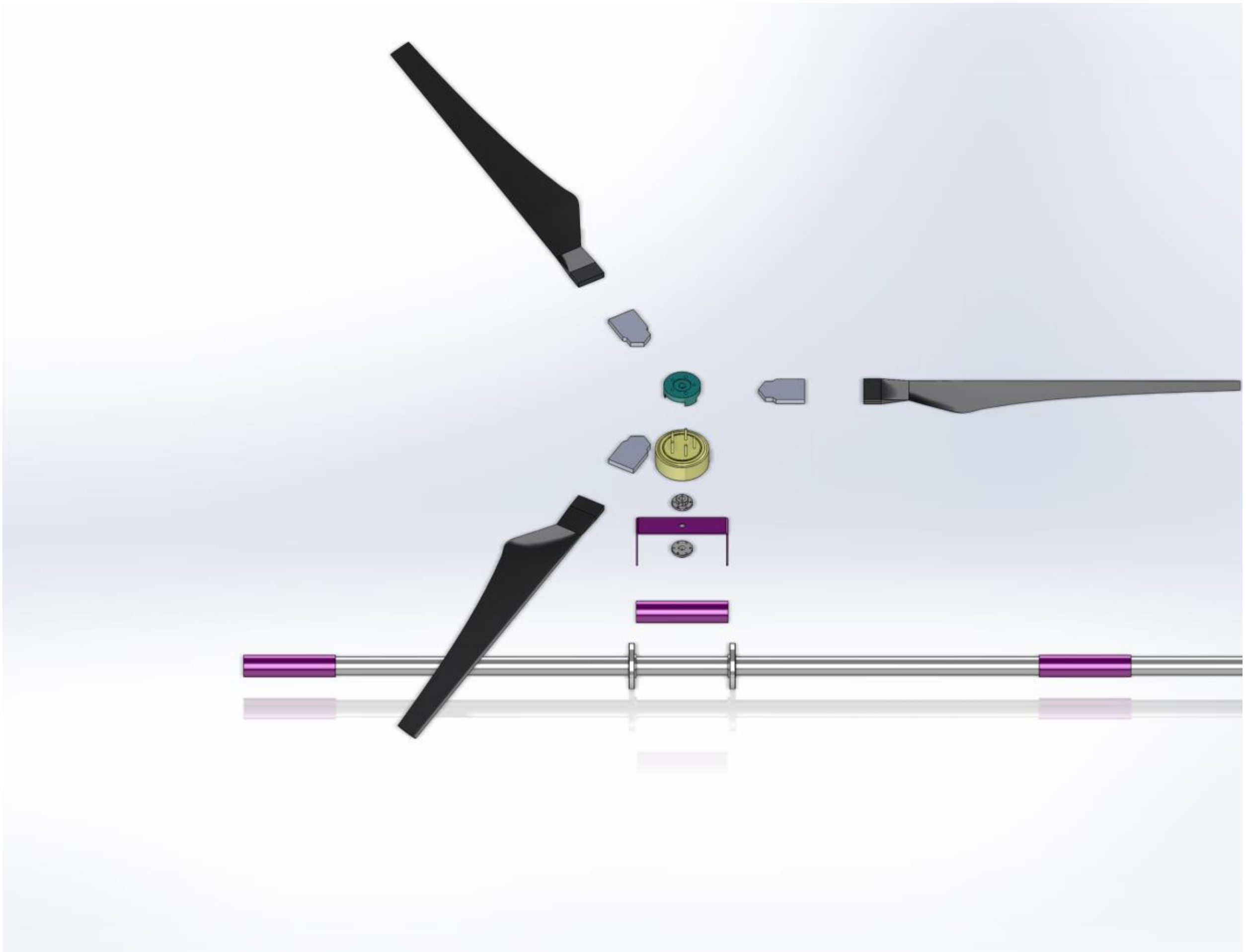


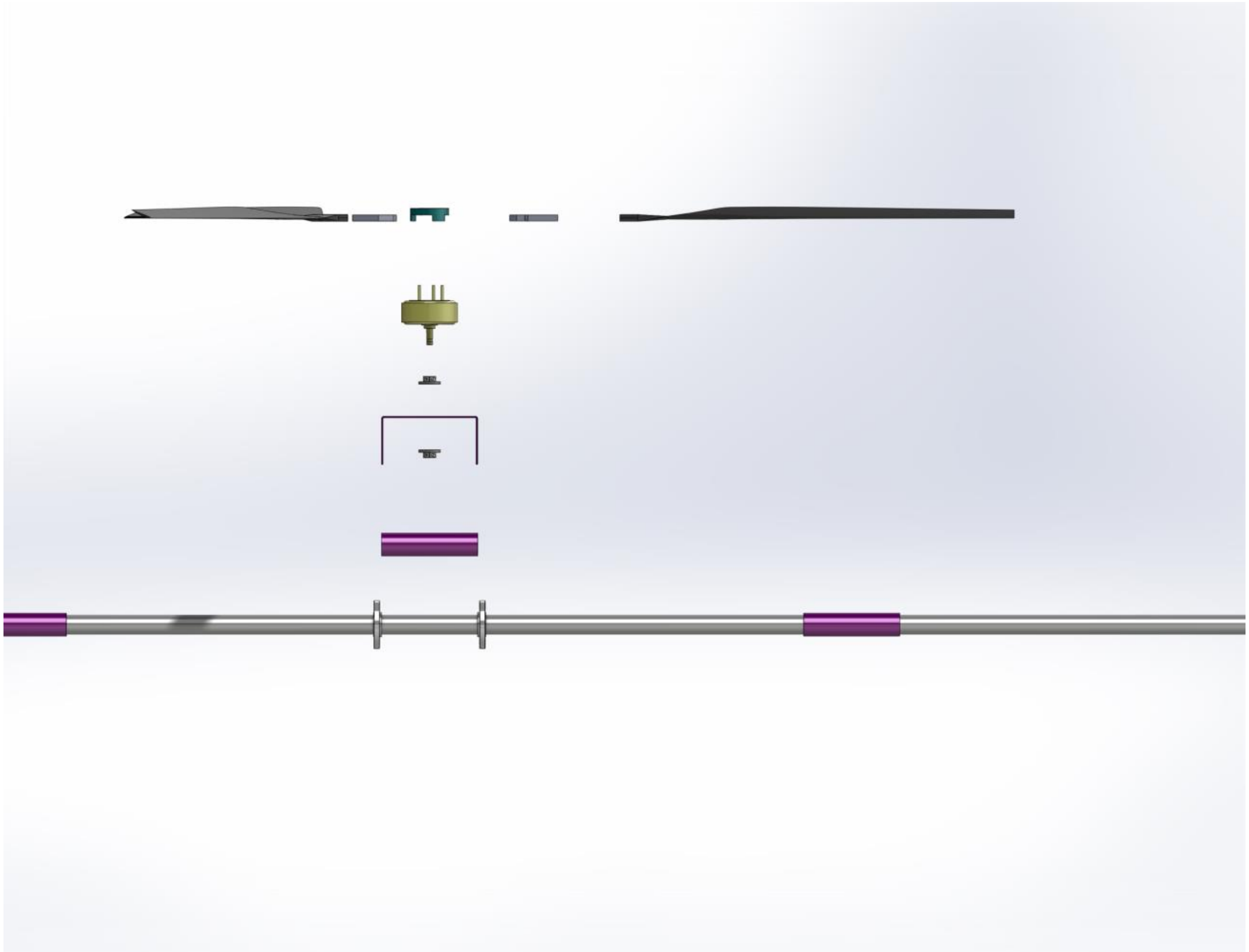


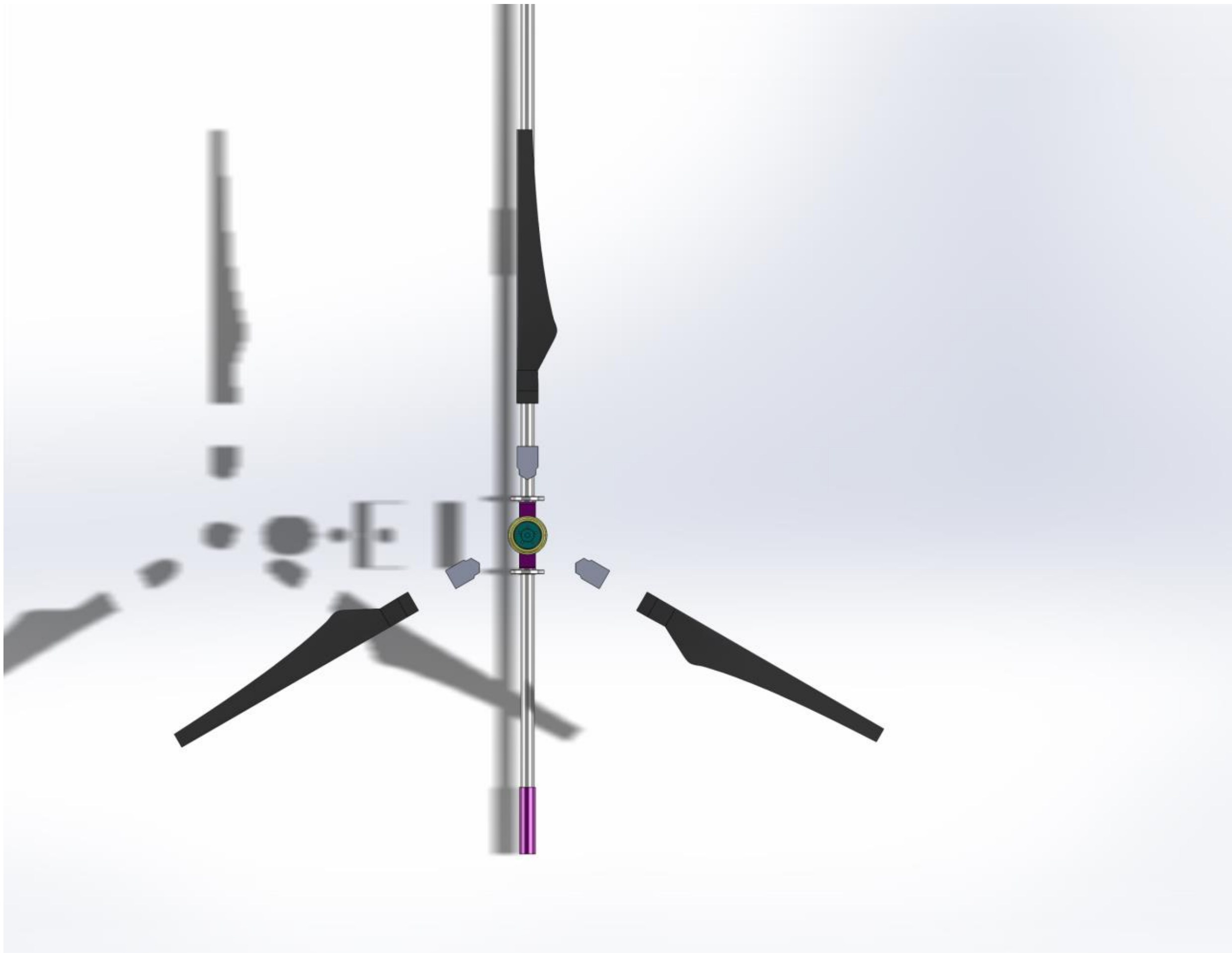


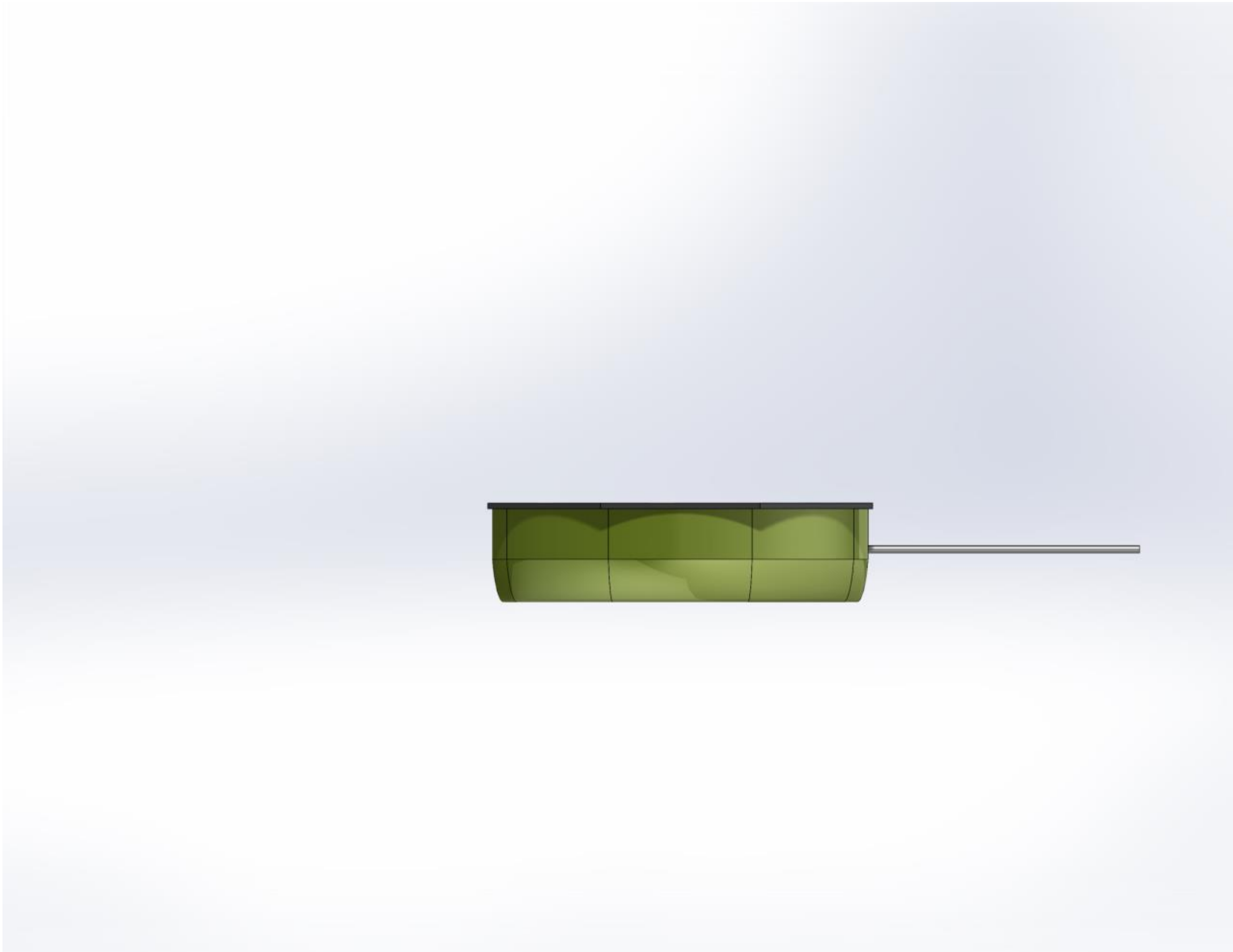


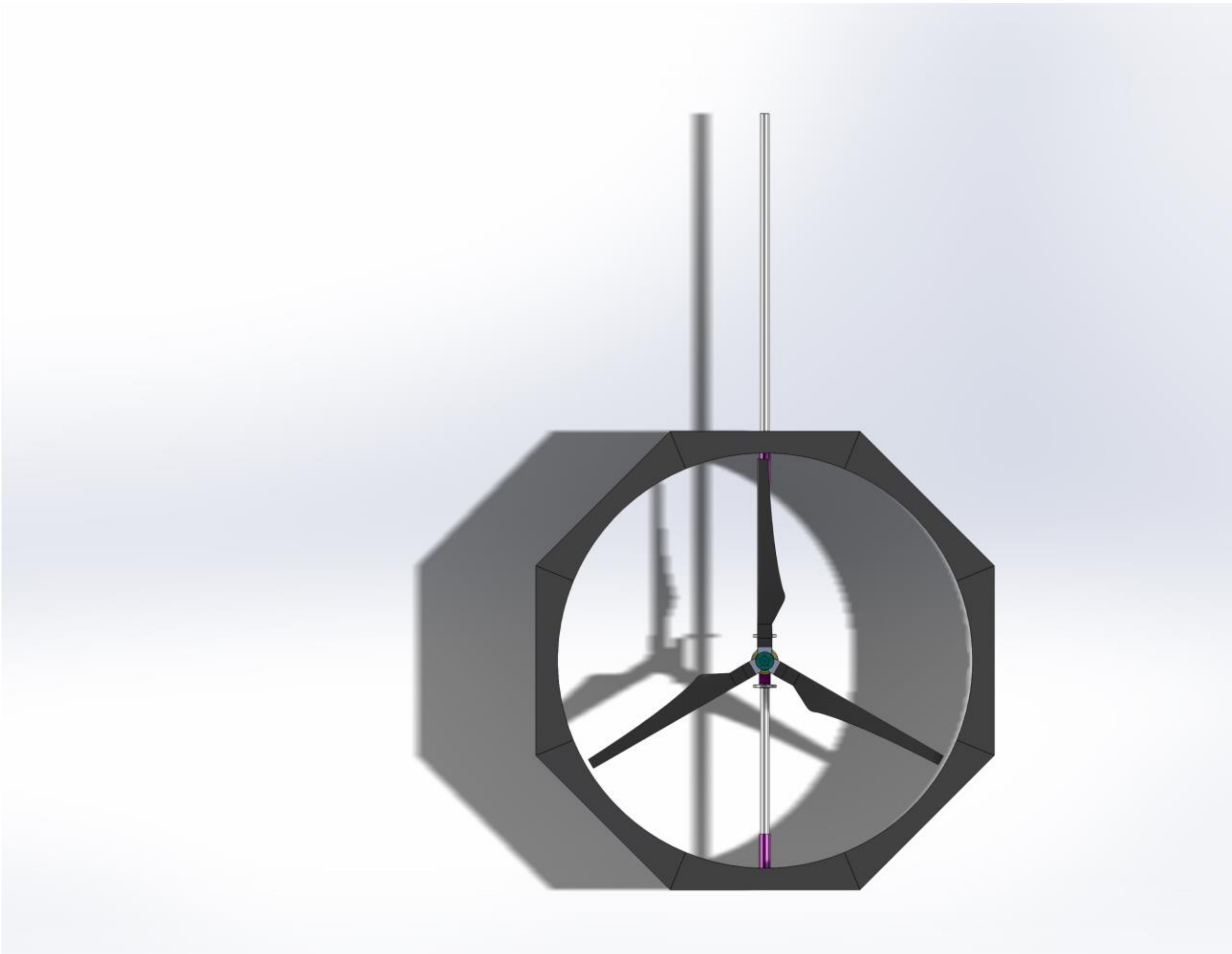












Front Row: Kristin Morrissey (With Zoey Morrissey, Canine Mascot in Arms), Alexandre Sampaio, Donna DiBattista, Christopher Daly, Peter Jones.
Middle Row: Isaac Grullon, Erika Sjoberg, Michael Dube, David Phung, Michael Schaefer.
Back Row: Jigar Patel, Christopher Hansen, Albert Andino, Dean Kennedy, David Willis, Stephen Johnston.

Not Pictured: Erik Anderson, Parth Patel, Meaghan (Maggie) Riley, Jeffrey Chung, Patrick Logan, Robert (Bobby) LeBeouf, Gregory (Greg) Lennartz, Christopher Niezrecki, Jack Wilson, Yi Yang, Ziyad Salameh.

Logo # 1 : Logo With text

Logo # 2 : Logo Without Text