Personal Project: The DIY KrazyKart

Introduction

I took inspiration from TaxiGarage, a company who professionally makes and sells KrazyKarts. There are many videos on the internet of people drifting their karts around town, going sideways around corners and having a great time. However, these karts are expensive, with the cheapest full sized (non-kids) kart starting at $900. Taking a closer look at their design, I saw how simple it was, and I thought it would be a fun project to make my own from scratch.

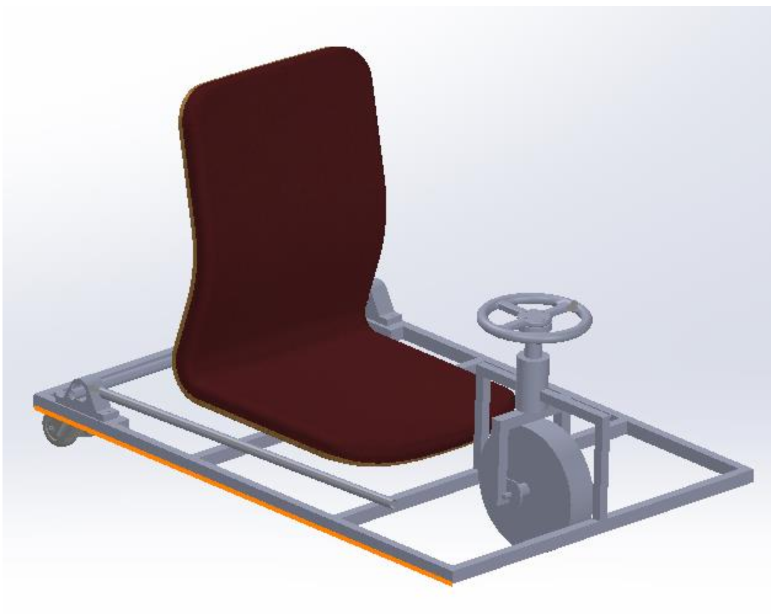
This report documents the end-to-end design, fabrication, and testing of a DIY electric “KrazyKart” completed as a solo, at-home build. The vehicle is a compact, low-speed, “go-kart” intended for maneuverable, playful handling on smooth surfaces. The system integrates a welded steel frame, a rental scooter electric hub motor paired with an aftermarket motor controller, 3D-printed components, ball bearings, and swivel caster wheels.

Design and Analysis

Philosophy

I wanted to create a design that was simple and most importantly, easily manufacturable due to the lack of manufacturing resources at home. Before this project started, I didn't have many relevant tools to fabricate the kart. So, for the project, I bought an old flux core welder for $40 on Craigslist, as well as other necessary welding accessories, a vice, and an angle grinder from Harbor Freight.

CAD Model



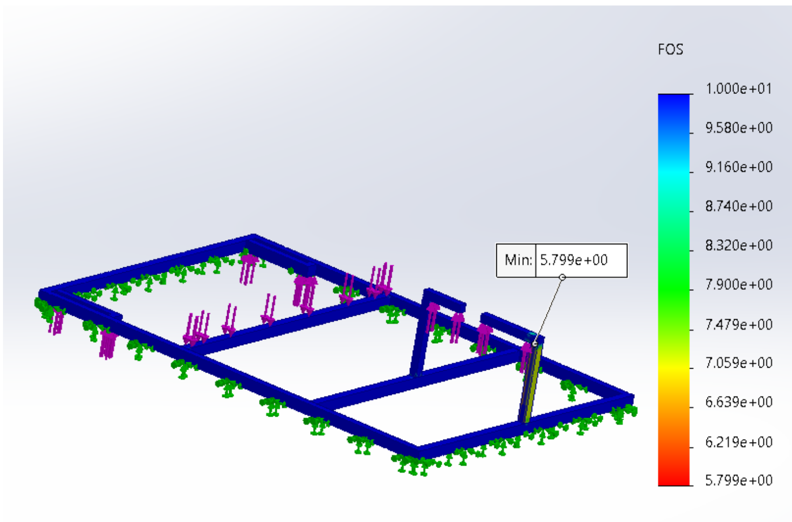
I got many of the parts for free. The scooter was a decommissioned rental fleet scooter which was going to be used for spare parts. My friend, who worked for the company, gave me this scooter. I stripped the scooter down to the frame to salvage the battery, controller, and hub motor. I got a seat from my local elementary school's trash pile which gave the kart a nostalgic feeling in the cockpit.

<u>Frame</u>

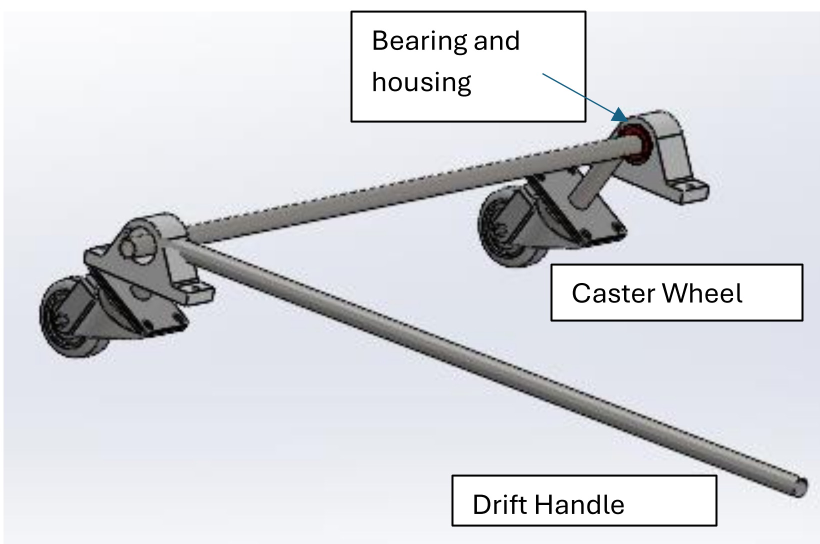
Starting with the frame materials, I used 0.75" mild steel square tube. I did this because it was the smallest tube size that I was able to use that could comfortably have

0.25" holes drilled into it. In terms of strength, I could have easily gone to a thinner tube to save money and weight. However, I knew that I was going to need to drill holes to mount the bearings for the drift bar.

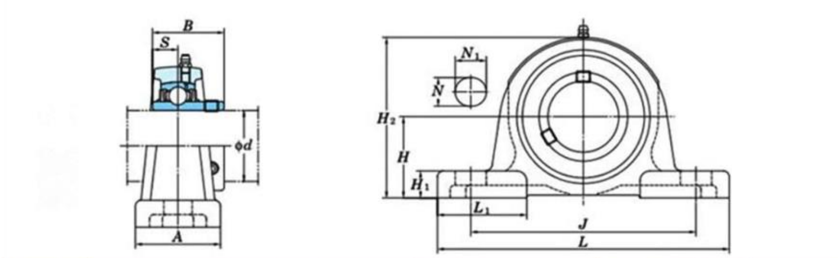
I ran an FEA on the frame to check the factor of safety. I fixed the bottom side of the frame, added a load of 200 lbs to the tube supporting the seat, and 100 lbs to the tubes supporting each of the wheels. The resulting FOS was 5.8 which is overkill for cruising around. But it could also withstand high acceleration scenarios such as hitting large and sharp bumps or going through compressions in a skate park. Specifically, it could withstand 5Gs of vertical force.



<u>"Drift Assembly"</u>

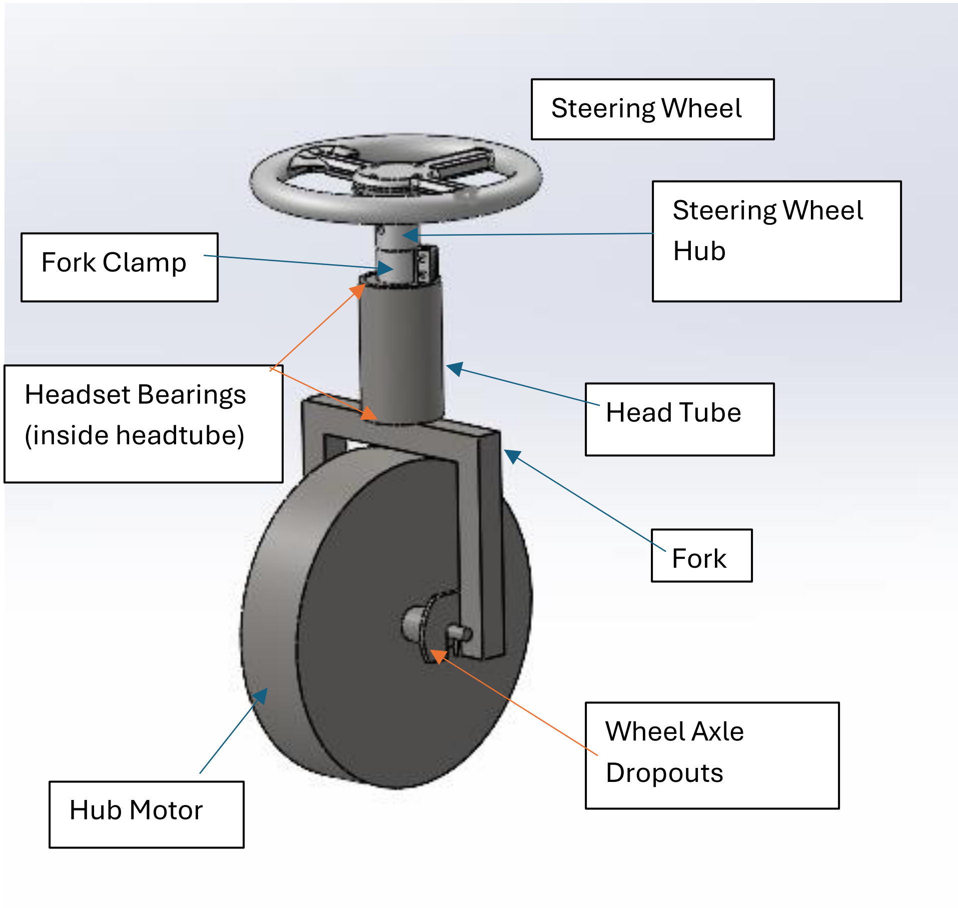


The way that the rear wheels "break traction" for a drift is via these two caster wheels. When the drift handle is in its normal lowered position, the caster wheel's steering axis is leading the wheel which makes the wheel want to track straight like a normal wheel. However, when the lever is pulled, the caster wheels go into a vertical position, allowing the wheels to freely swivel, hence allowing the back end of the kart to rotate (like a shopping kart going backwards). For the bearings and the housing, I found a set of block pillow bearings that came in the right inner diameter for my steel tubing. They were rated for a dynamic radial load of 12,800 N or 2877 lbs each which was more than overkill for what I was doing. It would have been nice to find a smaller set of these, but unfortunately for the given ID of 0.75", all the options on Amazon were similarly sized.



Shaft Diamter	Dimensions (mm)											Basic Load Rating/kN		Bolt Used	Bearing Number
d	H	L	A	J	N	N_1	H_1	H_2	L_1	B	S	Dynamic	Static		
15mm	30.2	127	38	95	13	18	12	60	38	31	12.7	12.8	6.6	M10	UCP202
20mm	33.3	127	38	95	13	18	13	64	38	31	12.7	12.8	6.8	M10	UCP204
25mm	36.5	140	38	105	13	18	13	71	43	34.1	14.3	14	7.9	M10	UCP205
5/8"	6.2	9	19.5	6.2	3.5	1.2	6.2	9	19.5	6.2	3.5	12.8	6.6	M10	UCP202-10
3/4"	6.2	9	23	6.5	3.5	1.2	6.2	9	23	6.5	3.5	12.8	6.8	M10	UCP204-12
1"	8.2	10	23	7	4	1.4	8.2	10	23	7	4	14	7.9	M10	UCP205-16

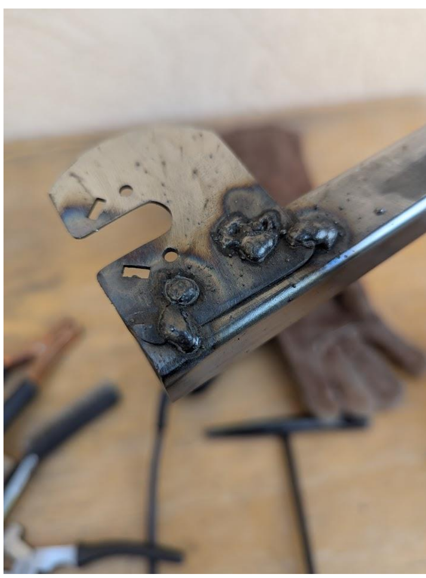
Steering Assembly

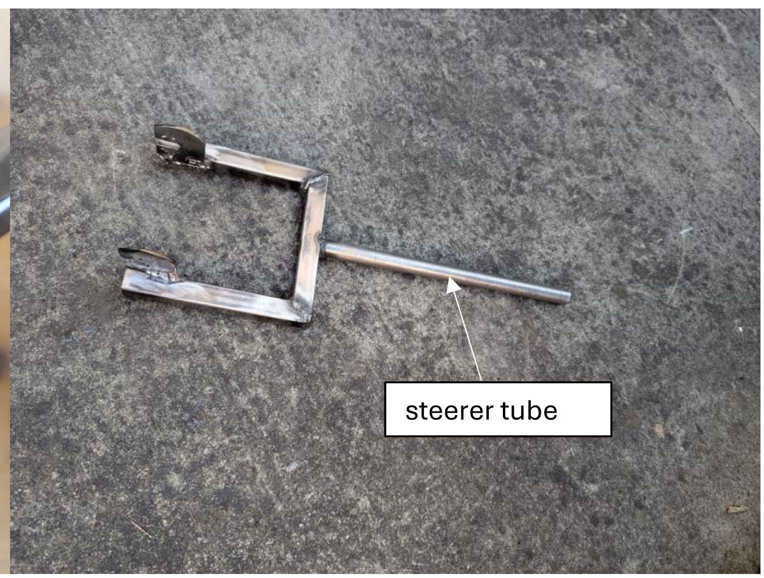


The steering assembly is designed like a bicycle's steering. The front wheel is attached to a fork, and the steerer tube of the fork goes through a headset, which contains the bearings that axially restrict the fork's movement. The headset bearings allow the fork to rotate and steer the bike. Furthermore, there is the fork clamp, which clamps onto the steerer tube and further fixes the fork vertically. Lastly, the steering wheel attaches to the hub at the top of the steerer tube. The hub is connected to the steerer tube via a transverse bolt. The front wheel attached is the hub motor from the scooter. The main benefit of using the hub motor over a normal motor connected to a wheel with a chain is the simple packaging.

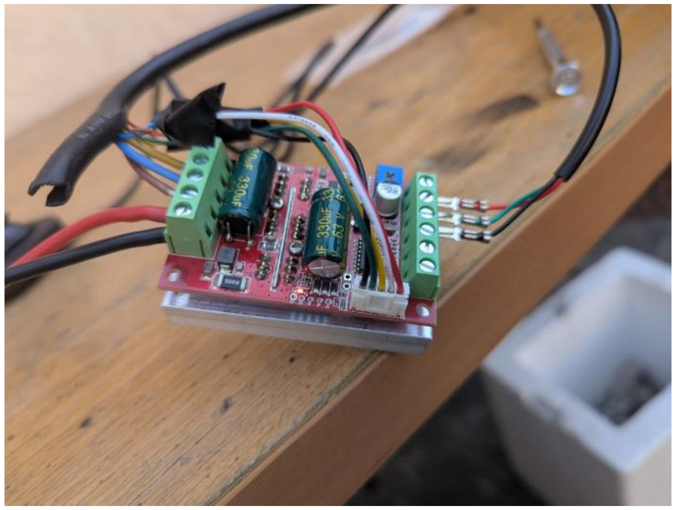
To connect the hub motor with the fork, I needed a way to attach a dropout. Unfortunately, the front fork from the scooter was too narrow to fit the hub motor, which came as the rear wheel of the scooter.

Fortunately, the rear of the scooter had detachable dropouts that were made of steel. So, what I eneded up doing was welding the dropouts to a steel fork that I designed and welded to fit the wheel. I used to the bolt holes on the dropout as a spot weld hole, which made welding it to the fork fairly easy, but very strong.





Controls



Sadly, since it was a fleet scooter, the BMS and the controller had some sort of security measure which prevented them from working without a signal from a separate security module which I had to cut the wires to. So, I had to buy an aftermarket BLDC motor controller off of Amazon. The new controller unfortunately did not have the same color coordinated wiring as the motor, so I had to keep on swapping the hall sensor and phase wires until I found the right combination. Eventually after lots of trial and error, I found the right wire combination and got the motor spinning smoothly and in the correct direction.

For the throttle, I used a throttle pedal I had found on Amazon. However, unknowing to me, the pedal output an analog 0.8-5v signal, when the controller expected a 0-5v PWM signal. This caused the wheel to move at all times, even with the pedal not being pressed, as it was always outputting 0.8vAt first, I did not know what a PWM signal was and why the voltage mattered. After some research, I realized that I could use an Arduino to change the analog input signal in a PWM output. With some quick coding and assistance from AI (ChatGPT), I got a working code which successfully converted the signal. Now the motor did not spin when the throttle was not pressed but spun as expected when the throttle was pressed.

Power/Battery

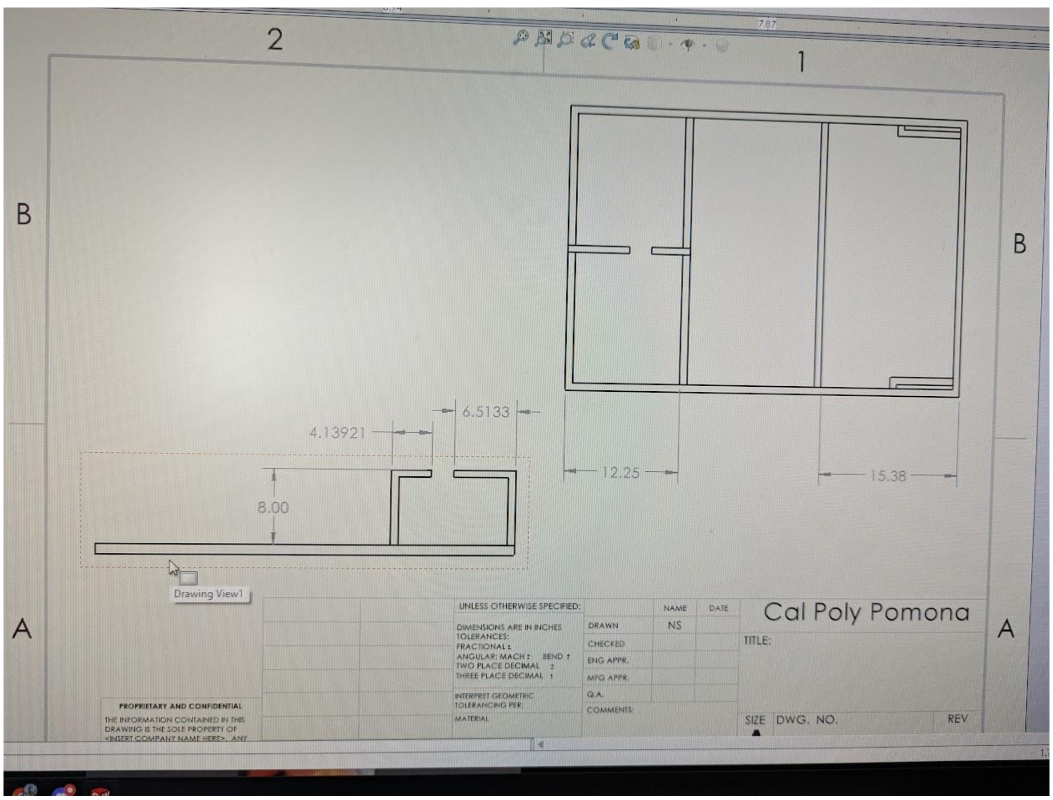
The Kart is powered by a 36V battery that I purchased off of Amazon. It is only 2.6-amp hours due to budgeting. Surprisingly, it was able to easily last two hours of kart usage.

Manufacturing

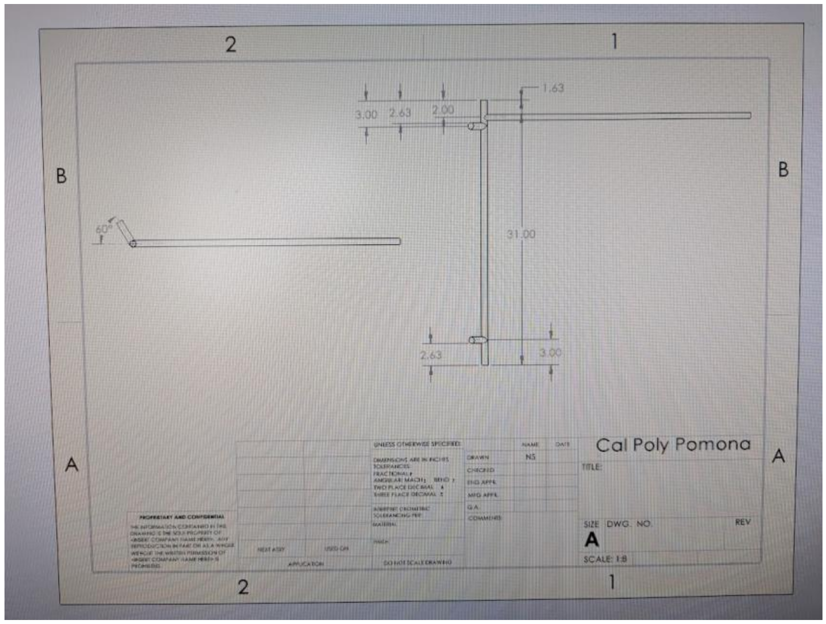
The manufacturing portion of the project took by far the longest time due to my lack of manufacturing experience, lack of proper tools, and a multitude of trips to my local Harbor Freight. However, after completing everything, I learned a lot about fabrication, as well as the importance of designing for manufacturing

Cutting/Notching/Grinding

I started off with a 10 foot long piece of steel tubing that I bought from a local metal market. Based of my CAD model, I cut it into pieces using an angle grinder. A band saw or chop saw would have been nice, but I had to work with what I had. I then made 45 degree cuts on ends of each piece to make a nice corner at the joints of the tubes. I did this for all the square tube cuts where there would be a 90 degree joint.



A more challenging cut was notching the round tubes to make the drift bar assembly. To make the notch, I used what my FSAE team calls the “paper trick”, which is when you make your tube in CAD into sheet metal, then unfold it to make it a flat profile. Then, after making a 1:1 scale drawing and printing it out, I had a paper template which I could trace the outline of the cut onto the tube.

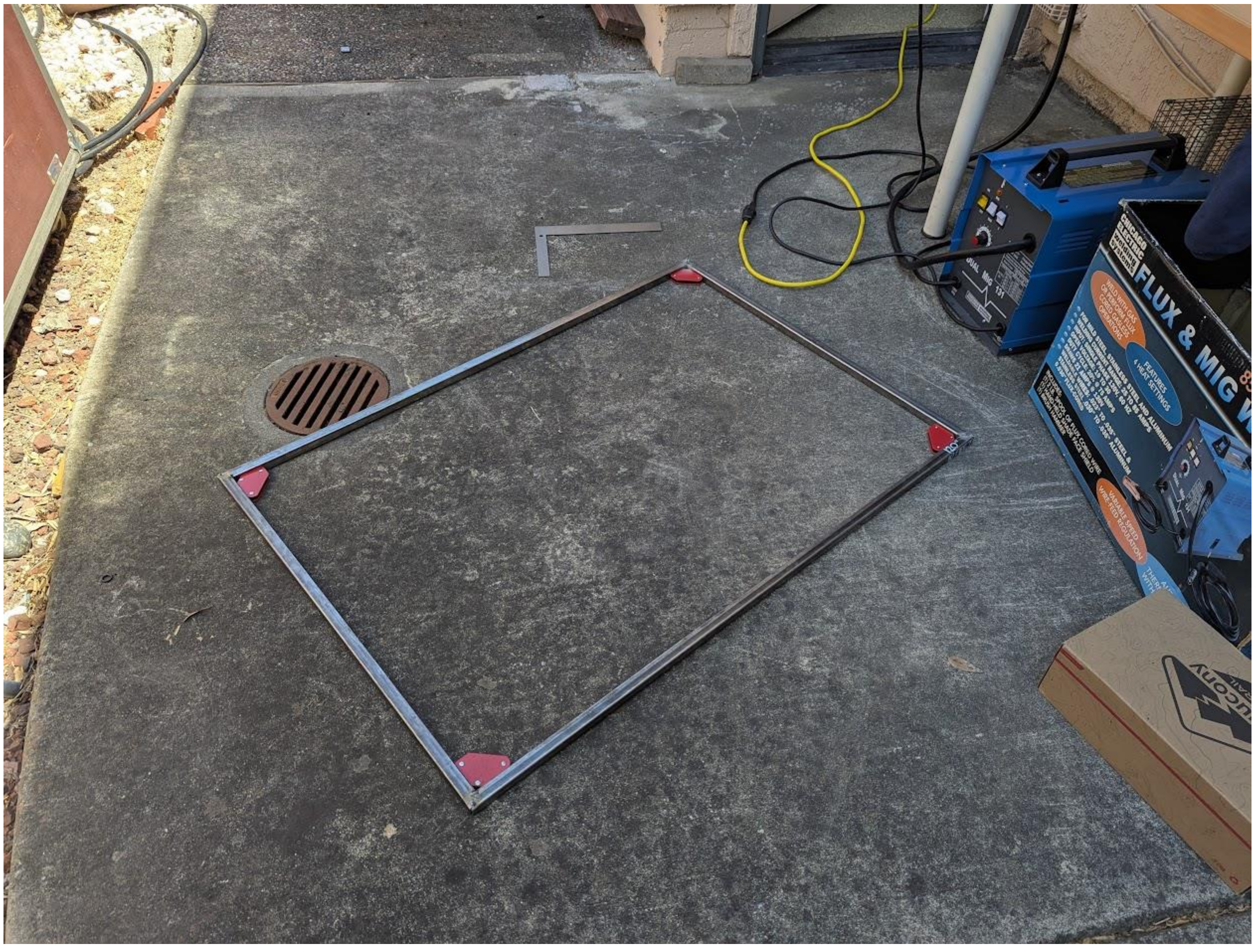

2
1
B
A
1.63
3.00
2.63
2.00
60°
31.00
2.63
3.00
UNLESS OTHERWISE SPECIFIED
Cal Poly Pomona
TITLE:
SIZE DWG. NO.
REV
A
SCALE: 1:8

Welding

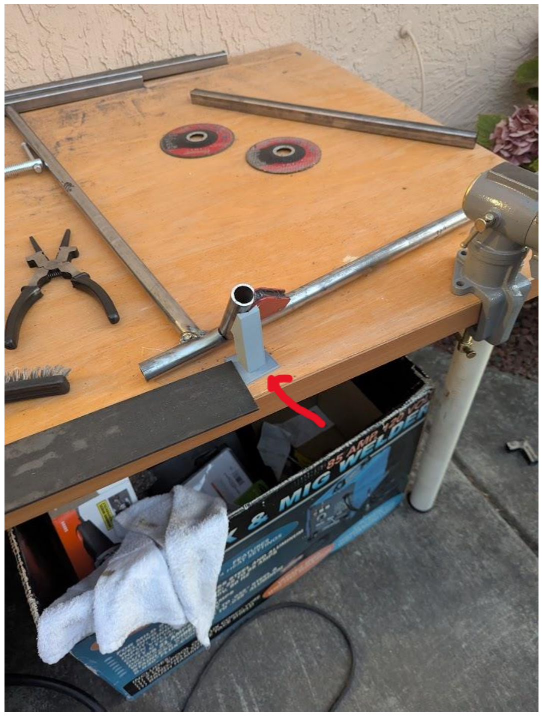
To weld, I got a 120V flux core welder off of Craigslist. It was a little bit difficult to weld without a proper welding and fixture table, as I had to clamp the ground directly onto the part which sometimes did not give a great ground. This caused the welder to sputter on and off, making a weld bead more like consecutive tacks. To remedy this, I ended up thoroughly cleaning the ground surfaces with a wire brush. This significantly improved the conductivity and thus, the quality of the welds.

Throughout the manufacturing process, I was experimenting with different welding settings and techniques to try and get a good-looking weld. At first, I would use low power and wire speed settings as I needed more time to think and look for the puddle while welding. However, as I got better, I was able to increase the voltage and wire speed while avoiding burning through the part. This resulted in better penetration, easier to scrape off slag, and shinier welds. I also experiment with different hand motions. After getting comfortable with going in a straight line, I started doing loops or going back and forth. Unfortunately, I did not have much success with either of the techniques. But I found that going in a C-shaped pattern gave me the best-looking welds, and I was easily able to control the puddle of the weld.

Welding the frame was pretty straight forwards. I just connected all of the 45 degree joints together with magnets and welded them. A small issue I came across was that since I cut everything by hand, some of the cuts were a bit off, resulting in gaps between pieces. So, I just filled the gaps with tack welds, grinded them down, and welded over the new bridge.



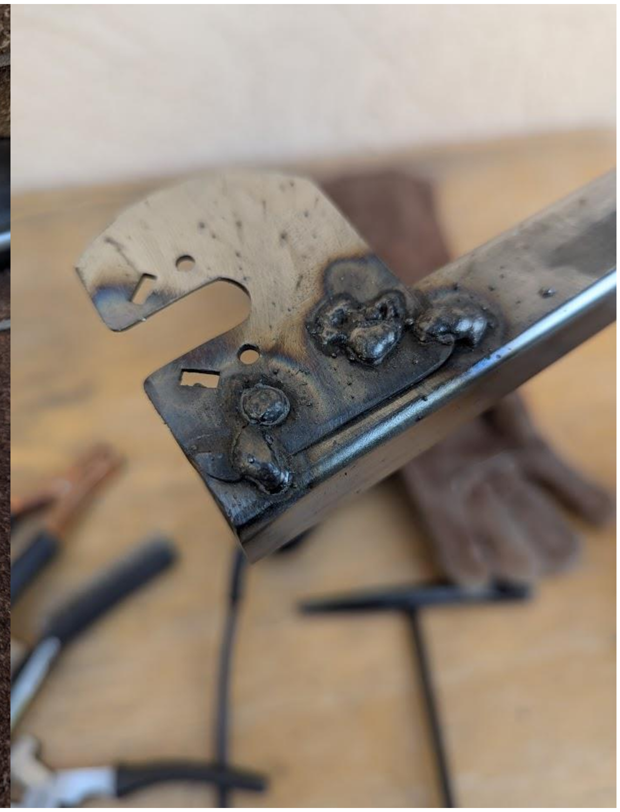
The drift bar was probably the most challenging thing to weld since it was round. A big challenge was fixing the tubes in place as I did not really make a jig for it. To get the correct angles for the caster wheels, I 3d printed a holder to try and get a somewhat uniform angle on each side. This actually worked really well and was very simple to make.

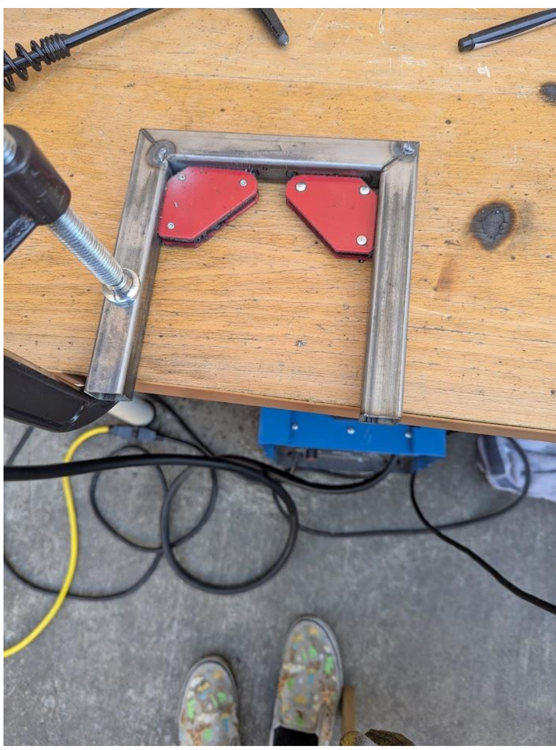


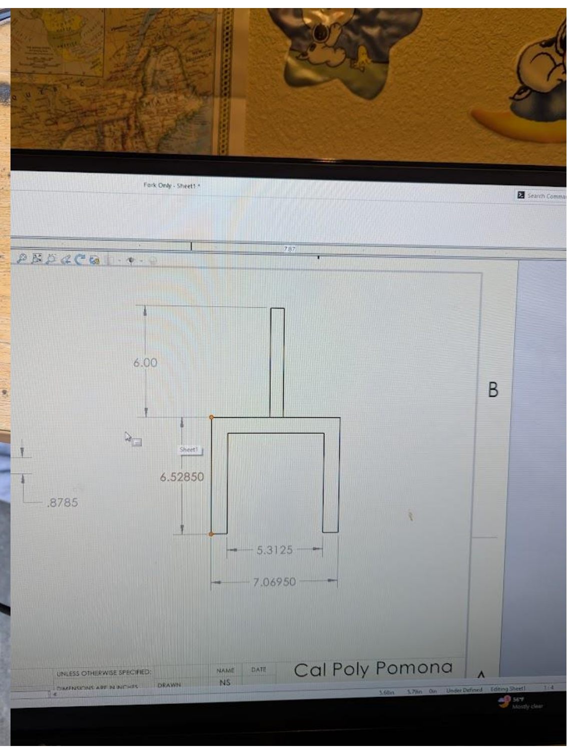
What I wish I had done was make a proper jig which I could easily lay all the tubes on and have them fit seamlessly without needing to tamper with anything to get the correct angles. I could have 3d printed pieces which would fit together in one way, then I could lay the tubes on them and have them be supported.

It also likely would have made it easier to weld the round edges of the tubes. The curvature of the weld torch path was something which I could not manage to grasp by the end of the project. The distance between the metal and the torch tip always deviated, which greatly affected the quality of the welds.

With the existing front fork not fitting the hub motor, I had to design and fabricate my own fork. To do this, I just measured the width of the original rear wheel dropouts, subtracted the thickness of the dropout itself, and that value was the inner width of the fork. Welding the fork was decently straightforward, similar to the frame. To weld the dropouts, I tacked the edges onto the fork like normal. Then I utilized the existing bolt holes on the dropouts to spot weld. This is something usually used in the automotive industry. It creates a very strong weld between the two parts by just filling in the hole with weld material, making sure to overlap it.







3D Printing

I 3d printed many parts on the steering assembly, including the steerer tube clamp, steering wheel, and steering wheel hub. They were all printed out of PETG due to the higher toughness compared to PLA, as well as the fact that it is fairly easy to print and doesn't release too many fumes which my mother was very concerned about. To slice, I used Cura where I controlled the wall thicknesses, infill, and support settings. I used around 1.6mm wall thickness and 1mm floor thickness, and 40% infill for the clamp, since that was the part that I had thought would be taking the most load, as I would be tightening the bolts of the clamp to be fairly tight so that it would grip the steerer tube.

Room for Improvement

Since this was the first iteration of my KrazyKart, there are many things that I know I can improve after building and testing it.

Floor

Having a wood floor on the kart was a last-minute decision, as I was extremely low on time and had to find some type of material I had around my house. I ended up finding thin 3/16" plywood which had been sitting outside of my house for years. Its condition was very poor, and its performance reflected that. It was too fragile and felt like your feet were going to go through it. It also did a bad job at supporting the electronics and the throttle pedal, making it hard to control the motor with your foot. Instead of wood, I ideally would want some sheet metal to use as the floor since it is stiffer, weldable, but still easily cuttable.

Electronics Fastening

When I first got the car driving, I did not really think about securing the electrical components. So, they ended up sliding off the kart when I hit a bump, disconnecting many wires. I was fortunate to not have any of them short, but that moment made me realize that I needed a way to secure the battery. Being short on time, I was able to 3D print a case for the Arduino. However, the motor controller and the battery were zip-tied or taped to the wood. Ideally, I would design and 3d print a large box where I could safely stow away all of the electronics. This box would have a lid to prevent anything from falling out if I were to hit a bump but would still have perforating holes for cooling and would be bolted to the sheet metal floor.

Stability

An issue that arose from testing the kart at the skatepark was how prone it was to getting speed wobbles. I believe this was caused by the steering angle of the fork being 90 degrees (vertical). Cars and bicycles typically have the steering axis angle away from the rider.

A longer trail length (and consequently slacker steering angle) gives the wheel's contact patch more leverage, increasing the self-aligning torque of the wheel and hence the stability. This change also puts the steering wheel in a more ergonomic position. Instead of having the wheel lay parallel to the ground, angling the head tube would make the wheel face the driver more. This could further improve the stablity of the kart as the driver will be in a better position to grip the steering wheel and keep it pointing in the desired direction of travel.

What I have learned

This project has taught me a lot about engineering design and manufacturing. Although I have learned about **DFM** in class, actually designing and then manufacturing it myself really showed me the importance of making smart design choices so that the fabricator does not hate you and have to spend extra time on something which could have easily been fixed in CAD.

However, as Murphy's Law states, whatever can go wrong will go wrong, so things are bound to not work perfectly in real life. This happened to me a multitude of times for this project. I learned how to **troubleshoot unexpected problems** that tend to happen during the course of a project.

Before this project, I did not really know much about DC electric motors. Now, I know about how to use and wire **motor controllers**, what types of power to provide, and using **Arduinos** to change signals

Lastly, I learned how to **weld**. Although this may not be critical for an engineer, learning to weld has also taught me how the entire process works and that designing appropriate jigs will make a welder's life a lot easier, lead to faster production times, and lead to lower production costs.

Bill of Materials

Bearing Cart						
Level	Part	Description	Supplier	Qty	Unit Cost	Total Cost $
	0.75" Sq Tube	300 inches	Metal Supermarket	1	$0.22/in	$65.08
1	Frame	258.149 in of tube used	Metal Supermarket			$0.00
2	0.75" Sq Tube	cut pieces to 43"	Metal Supermarket	2	$0.22/in	$0.00
2	0.75" Sq Tube	cut pieces to 30"	Metal Supermarket	2	$0.22/in	$0.00
2	0.75" Sq Tube	cut pieces to 28.5"	Metal Supermarket	3	$0.22/in	$0.00
3	Bearing	Block Pillow, .75" ID	Amazon	2	$7.50 per	$15.00
4	All Hardware	Metric Nut, Bolt, Washer	Harbor Freight (HF)	1	$5.99 per	$5.99
4	M6 Nuts and B	Block Pillow Hardware	Harbor Freight	4		$0.00
2	Drift Tube	0.75" Round Tube 72" tot	Metal Supermarket	1	$0.42/in	$29.93
3	0.75" Rnd Tube	handle and bar 30"	Metal Supermarket	2	$0.42/in	$0.00
3	0.75" Rnd Tube	for caster wheel mount	Metal Supermarket	2	$0.42/in	$0.00
3	Casters	came with hardware	Amazon	2	6.42	$12.84
2	Fork Assembly					$0.00
3	Head Tube	for fork	Metals Depot	1	$8.17	$8.17
3	0.75" Rnd Tube	12" long	Metals Depot	2	$4.42	$4.42
	0.8785" Sq Tub	~100"	Industrial Metal Sup	1	$7	$7.00
3	0.8785" Sq Tub	6.5"	Industrial Metal Sup	2		$0.00
3	0.8785" Sq Tub	7"	Industrial Metal Sup	1		$0.00
4	Headset Bearir	.75" ID, 2" OD	Amazon	2	$7.39	$14.78
	PETG Filament	1kg roll	Amazon	1	$13.99	$13.99
3	Steering Whee	3D printed, unknown weight		1		$0.00
3	Steering Whee	3D printed, unknown weight		1		$0.00
3	Steerer Clamp	3D printed, unknown weight		1		$0.00
4	M5 Nuts and B	For Steering wheel to hul	HF	4		$0.00
4	M5 Nuts and B	To secure clamp	HF	2		$0.00
4	M5 Nuts and B	To fix S.W hub	HF	1		$0.00
3	Arduino Box	3D printed, unknown weight		1		$0.00
2	Seat	Free from Dumpster	Trash	1		$0.00
2	Powertrain					$0.00
3	Motor 350W	salvaged from scooter	Friend	1	0	$0.00
3	Throttle Pedal		Amazon	1	$15	$15.00
3	36v Motor Con	with wires	Amazon	1	$19	$19.00
3	36v Battery	2.6 Ah	Amazon	1	$40	$40.00
3	Arduino R3	came in a kit	Amazon	1	$36	$36.00
4	Wires	came with arduino kit	Amazon	5		$0.00
						$287.20

Tools

Tools Purchased				
Item	Supplier	Qty	Unit Cost	Total Cost
Flux Welder + Gear	Craigslist (used)	1	$40.00	$40
Angle Grinder	HF	1	$15.00	$15
Welding Magnet x4	HF	1	$4.49	$4
Slag Hammer	HF	1	$6.00	$6
Wire Brush	HF	1	$1.00	$1
Weld Plier	HF	1	$12.00	$12
Clamp Vice	HF	1	$25.00	$25
8x12 Square	HF	1	$4.00	$4
Square Rafter	HF	1	$3.00	$3
Cutting Wheels x10	HF	1	$8.00	$8
Flap Disc 60 grit	HF	1	$5.00	$5
Flap Disc 40 grit	HF	1	$5.00	$5
Automatic Punch	HF	1	$4.00	$4
				$132