Feiyu Wu
12/11/2021

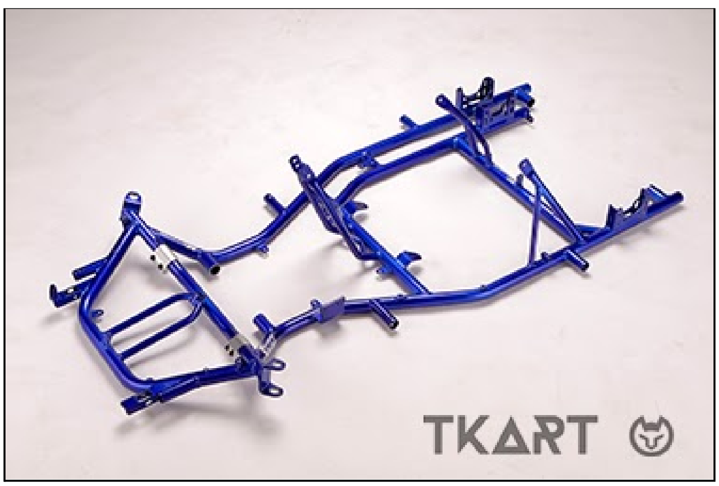
Personal Project Report

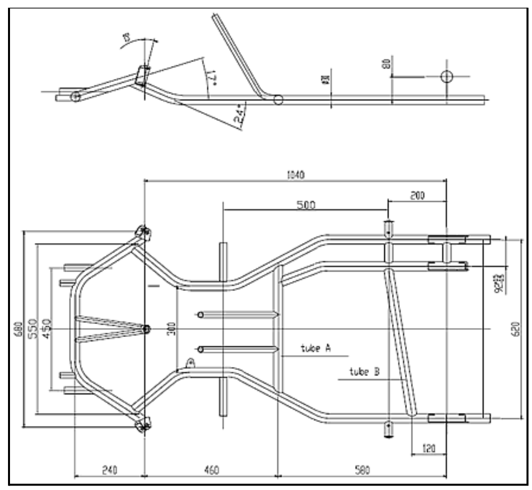
Feiyu Wu

Planning

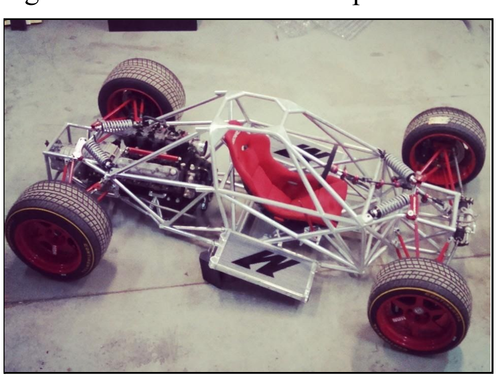
Ever since I drove the go-karts at Fort Fun, I was obsessed with a machine made of metal, 4 wheels, and a steering wheel. I have always dreamed of owning my own car, being able to drive myself to places, but I am not old enough yet. So for my personal project, I choose to build my own vehicle, a go-kart. My goal is to design and build a go-kart frame and research parts - wheels, gears, chains, etc. - that I will need for the go-kart to run. Throughout the project, I want to learn how to design a safe and sturdy go-kart frame, weld the frame, and work with engines.

My plan for this project is to do some research on the fundamental basics of a go-kart: what type of engines are used, how big the wheels should be, gear ratios, etc. After doing some research, I noticed that the shape of a go-kart frame is all the same.





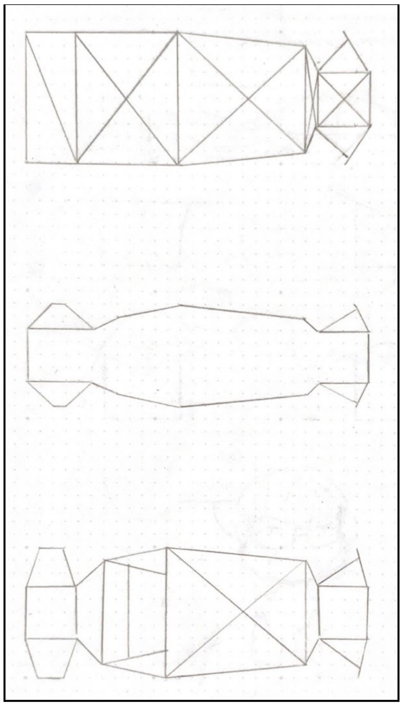
It is generally on a flat plane and really compact. One concern that I had with this design is its safety. Although you can add bumpers to it, there are no doors/walls around the driver, meaning that your arms and body would be exposed. Instead, I decided to design my own frame, making it more like a car roll cage so that the driver will be protected all around.



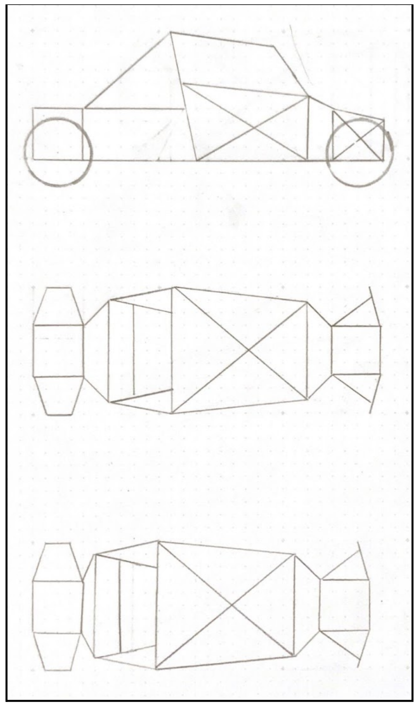
Feiyu Wu
12/11/2021

Applying Skills

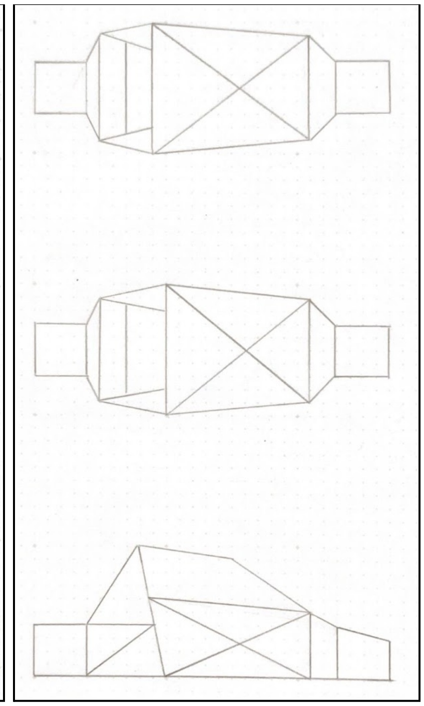
For designing the go-kart, I first made some sketches in my notebook. My goal was to get a rough idea to build off of.



Picture 1



Picture 2

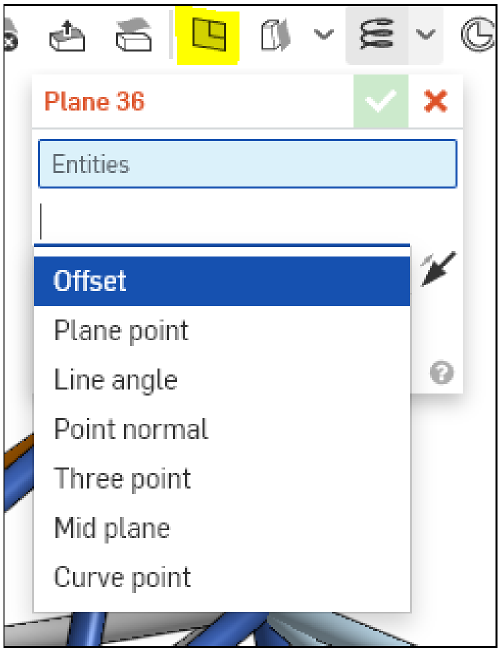


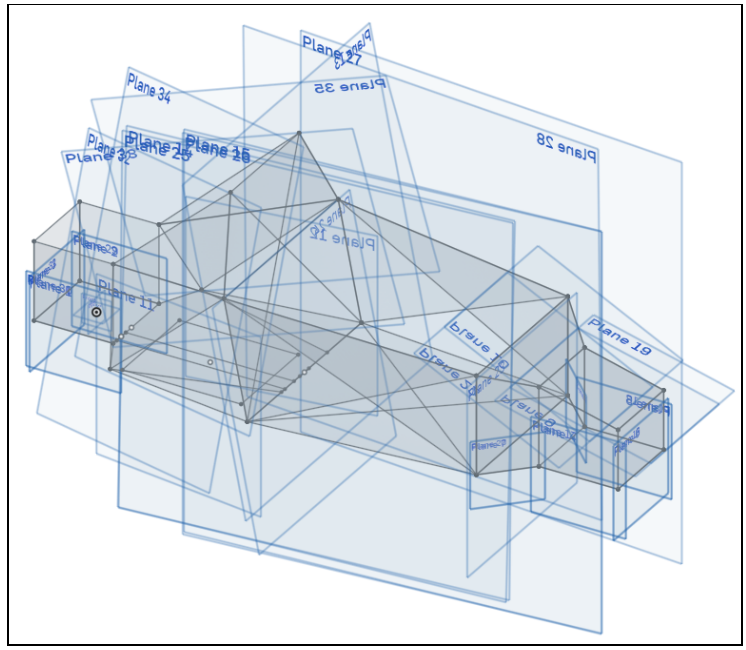
Picture 3 (1 grid = 10 cm)

I put organized all of my brainstorming in my notebook so that I can have easy access to them when I 3d model it on Onshape.

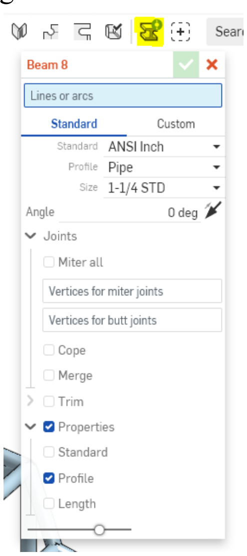
I first started with getting the basic shape of the bottom layer. I started with a “boxy” shape but then tried to “round” some edges so that it would be easier to make triangles. The second drawing in the first picture is the general shape that I used but it was too thin, so I widened it to 1 meter wide. I continued to try different dimensions for the engine bay and driver seat, making sure there is sufficient space. For the final design, the driver seat was about 1x1.1x1m (WxLxH), the engine bay was 1x.8m (WxL), and the overall frame was 1x2.9x1m (WxLxH). In order to make a strong frame, I incorporated triangles into my design. The triangles have a strong base and strong support, it will also maintain their shape, ensuring minimum flex in the frame.

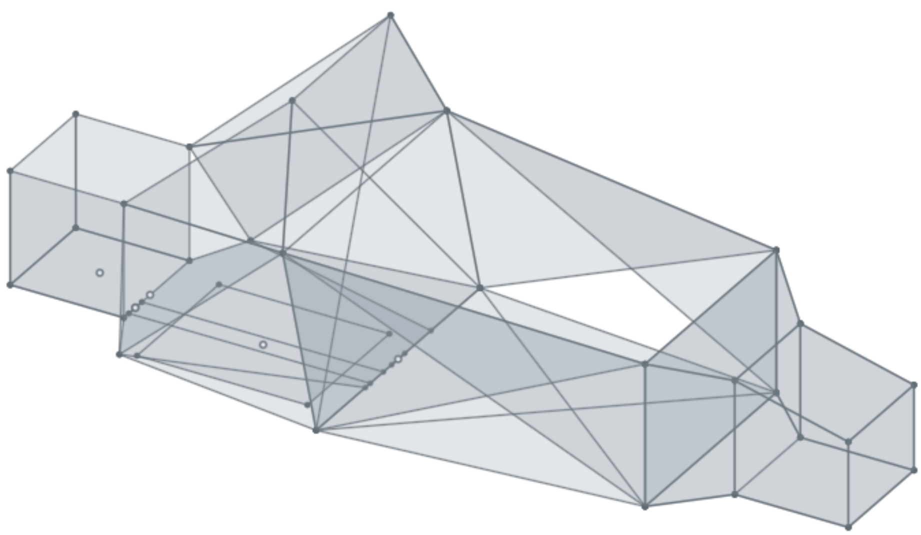
After I finished the sketches, I 3d modeled it on Onshape, which is a 3d modeling software that I have experience from working on previous school projects. Although I was pretty familiar with Onshape already, there were still some techniques that I had to learn in order to model the go-kart accurately.



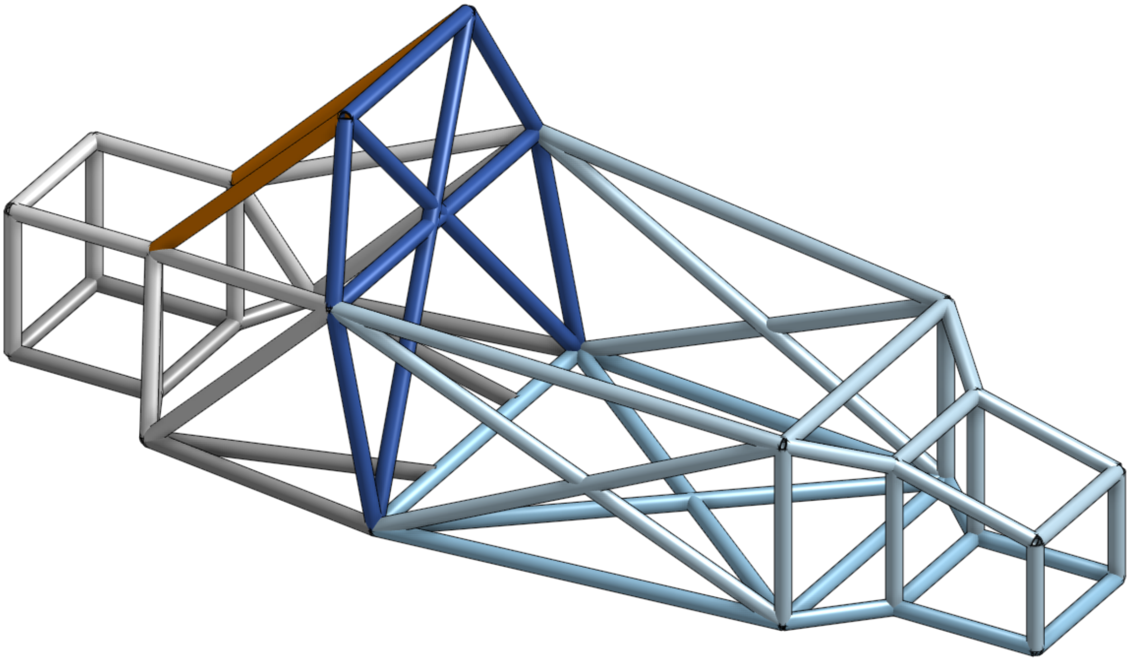


The plane tool allowed me to make planes at different angles, which then let me create sketches. I then learned to use the beam tool to turn the sketches into tubes, just like the tubes I will be using to build the go-kart frame.





Feiyu Wu
12/11/2021



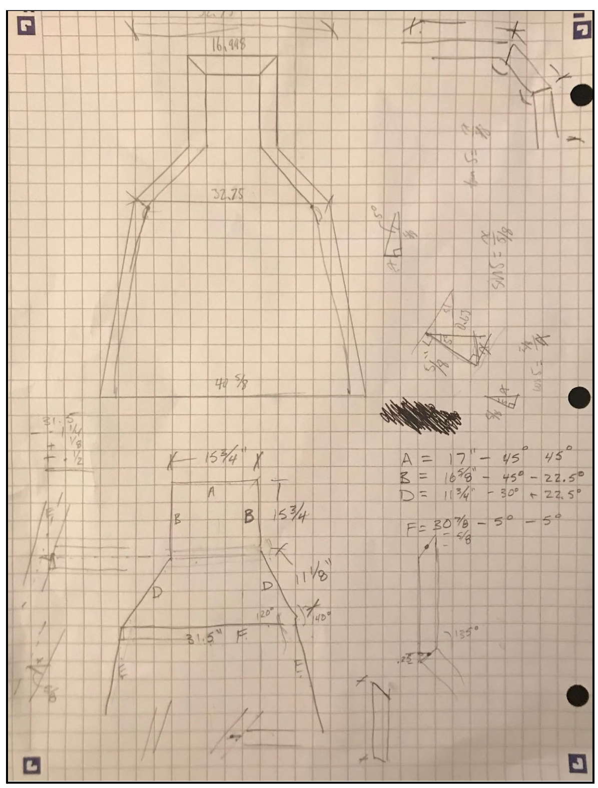
After finishing the design of my go-kart frame, I started researching parts that I would need and made a parts list. This required a lot of organization skills. First of all, I had to find all the required parts to make the go-kart run: engine, transmission, axles, bearings, sprockets, wheels, tires, steering shaft, and a lot more. After finding all of the required parts, I then looked into parts that would make the performance and safety of my go-kart better, parts such as exhausts and mufflers, racing harnesses, helmets, etc. I had to organize all of these parts into a google sheet by categories: drivetrain, steering, engines, wheels, etc. One of the hardest parts of finding the parts was the compatibility of the parts. It was very difficult finding parts that fit with one another. For example, in the engine and axle sprockets (gear), there are different-sized teeth and chains. I used the chart below to help me figure out what is the best-sized chain for my go-kart and if it would fit with the sprockets.

Go-Kart Chain Size Chart

Chain Size	Pitch	Roller Diameter	Roller Width	Pin Diameter	Tensile
35	3/8"	3/16"	3/16"	1/8"	2,100
40	1/2"	0.312"	5/16"	0.156"	3,700
41	1/2"	0.306"	1/4"	0.141"	2,000
410	1/2"	0.306"	1/8"	0.141"	1,600
415	1/2"	0.306"	3/16"	0.141"	1,600
415H	1/2"	0.306"	3/16"	0.141"	1,600
420	1/2"	0.306"	1/4"	0.156"	3,700
425	1/2"	0.312"	5/16"	0.156"	3,700
428	1/2"	0.335"	5/16"	0.177"	4,200
428H	1/2"	0.335"	5/16"	0.177"	4,200
520	5/8"	0.4"	1/4"	0.2"	6,100
520H	5/8"	0.4"	1/4"	0.2"	6,100
520-2	5/8"	0.4"	1/4"	0.2"	12,200
525	5/8"	0.4"	5/16"	0.2"	6,100
530	5/8"	0.4"	3/8"	0.2"	6,100

Another problem that I ran into while choosing the parts was finding the right transmission. There are generally two types of transmission for go-karts, the torque converter and centrifugal clutch. Torque converters are better for lower-end torque and they have the ability to adjust the gear ratio according to the engine's RPM. This makes it ideal for off-road vehicles. On the other hand, centrifugal clutches maintain the same gear ratio which is suitable for lightweight go-karts and for reaching maximum speed. Originally, I thought of using a centrifugal clutch because I wasn't building an off-road go-kart and it could reach higher speeds, but I realized that it was very difficult to find the right centrifugal clutch and my go-kart is going to be heavier than average racing go-karts. For my go-kart, I am going to use the Predator 670cc V-Twin horizontal shaft engine which produces about 22 horsepower. It was very difficult to find a centrifugal clutch that can handle such power. The clutches that I found were either too small to handle the power or cost over $1000. So instead, I decided to use a torque converter which generally can handle much more power.

After gathering all the parts that I need, I found a welding shop and a mentor. I contacted Distinctive Welding Inc.'s owner, Caleb. I scheduled a meeting with Caleb and we discussed what my project is, how long it'll take, and what I wanted to learn. We also went over some safety gear that I needed for the project: a welding hood, safety glasses, gloves, jeans or cotton clothing, and leather shoes. The clothing was crucial for my safety because if the material isn't jean, gotten, or leather, it will catch on fire very easily. Lastly, we discussed what type of tubing I will be using for the go-kart frame. Originally, I planned on using AISI 4130 (Chromoly)because of its lightweight and strength, which has a tensile strength of 560 MPa, it was also a very budget-friendly option; but the price of AISI 4130 has doubled over the past year due to high demands. Instead, Caleb and I agreed on using 1" schedule 40 pipes which had a similar tensile strength of 470 MPa. We estimated the amount of tubing I would need for my go-kart frame and ordered the parts. For the first couple of times that I went to the welding shop, Caleb taught me how to use a band saw and the basics of welding. My first task was to create a 4x4x4" cube out of rectangular tubes. This was to help me grasp how I will be putting my go-kart frame together. I first used the band saw to cut 12x 4" long pieces. The hardest part of using the band saw is eyeballing where to cut when cutting at angles. I then put them on a table in the shape of a square, using a right angle to make sure all of the angles were 90 degrees. One important technique that I learned while making the cube is to first tack (making a small spot of weld) all of the pieces together on both sides, then weld the edges together. This was a crucial step because if you start welding the entire side, the heat and weld will pull the pieces together on that side, making it bend in and not on a flat plane anymore. When you tack the pieces on both sides, it will make it so that when you weld one side, the tack will hold the pieces in place on the other side, keeping the two pieces from bending in on each other. This technique will come in handy when building my go-kart frame, it will help keep the bottom part of my go-kart on a plane easier. After I had gotten enough practice with welding and the tubing arrived, we started working on the actual frame of my go-kart. Caleb taught me how to use the forklift to take the tubing off of the rack. We walked through how to make a cut list, a list of parts with measurements to cut.

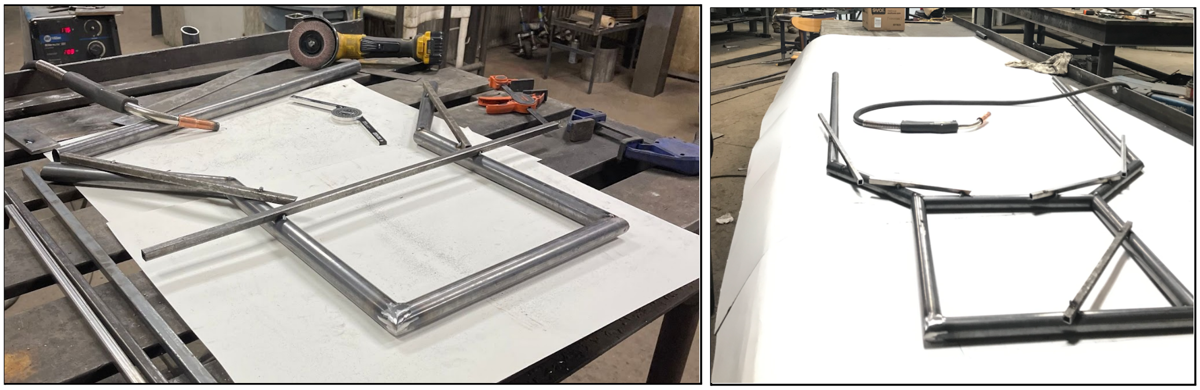


Feiyu Wu
12/11/2021

Since I modeled my go-kart frame on Onshape with lines, I had to add the width of the tube. I used the “outline” function on Onshape to widen the actual frame by half of the width of the tube so that I can get the actual measurements. After creating the cultist of the bottom part of the frame, I started drawing the frame on paper to scale. Caleb explained how he made all of his employees do this because when tacking and welding the parts together, you can put it over the drawing to check if the angles fit. The first time that I drew the frame, it wasn’t symmetrical. One of the biggest causes of this is that I used a protractor to measure the angles. Although protractors can be very convenient, it was very difficult to measure accurately. Since the lines I was drawing were so long, just half a degree off can end in a 2-3 cm difference. Instead, Caleb explained to me how to use the Pythagorean theorem and trigonometry to create a more accurate drawing. I used Onshape to find the “a” and “b” leg of a right triangle, I drew them both at a 90-degree angle on the paper, then connected the two ends with a ruler. Another way I learned to make the drawing more accurate was to use the line on the center of the paper. After drawing the frame symmetrical to the middle line, I used the middle line and measured the distance from the middle line to both sides, which should be equal. After finishing the to-scale drawing, I started cutting the pieces. Caleb also taught me how to use the miter saw. The miter saw made it much easier to cut at precise angles, although it was still hard to line up the tubing because you also had to eyeball it. Another thing I had to pay attention to while cutting with the miter saw is the orientation of the tube, I had to make sure that it was upright. In order to do so, I used a bubble level on one side of the tube, making sure that it is on a vertical plane. This made it much easier when it came to assembling all of the pieces and making sure they lined up correctly.

Miter Saw

With the parts cut, I started lining them up on the drawing I made, making sure the length of the tubes was right and the angles matched. With the parts in place, I first used a half-inch rectangular beam that was about a foot long to tac the two pieces together. This piece could be easily removed after I finish welding the frame with a half-inch wrench. This piece, similarly to tacks, was to hold the two pieces I am welding together at the right angles. After the rectangular piece is tacked on, I put a tack on the top side. With all of the pieces tacked together, I flipped the frame (bottom piece) over to tack all the joints on the backside. These two tacks were to make sure the pieces won’t bend when welding it out. Lastly, I added a couple more tacks on each joint to ensure the flat shape of the frame.



Using the drawing to line up and tack the pieces together. You can see the ½” rectangular pieces that I used to tack the pieces together.

After all of the pieces on the bottom part of the frame were tacked together, I started welding them out. While welding the joints, at some joints, the heat from the welding gun would melt the metal tubing away. This is due to the thinness of the tubing and the extreme amount of heat it is receiving and it causes holes in the joint. In order to fill the hole up, I had to lower the voltage of the welding gun so it wouldn’t melt away more of the metal. Then I made small tacks around the whole, making sure I take 1-2 second breaks between each tack to let the metal cool down. I kept making small tacks around the hole, making the hole smaller and smaller, until it closed. Lastly, I added more weld on top of the tacks to make it thicker and stronger. Originally I thought that filling up a hole like this would make the joint weaker, but Caleb explained how it may be even stronger because the weld is thicker than the actual walls of the tubing. When I finished the bottom layer of the frame, I started grinding the welds out with an angle grinder. This was a long process because I had to take breaks in between sessions of grinding due to the vibrations of the angle grinder, which caused my hand to fatigue and numb. An important thing to remember while grinding is to make sure that you grind it until it’s flat to the tubing. If you grind more, it will make the area concave to the surface, making the tubing weaker because it makes the walls even thinner.

The finished bottom layer of the go-kart frame.

After finishing the bottom layer, I started building up, although I ran into a problem. The bottom layer of the frame wasn’t completely flat, which would make it difficult to make the frame symmetrical and sturdy. To solve this problem, Caleb helped me clamp the frame down to the table so that it’s flat, then when I finish with the rest of the frame, the frame should keep the bottom layer flat. Building up on the frame wasn't much harder. I followed the process of making different sections that are on a plane first, then propping them up with half-inch rectangular beams. With all of the different parts of the frame done, a couple of the other workers in the shop helped hold them in place at the right angle while I tacked them with the half-inch beams. I made sure that the tacks on the beam weren't too large so that they could be adjusted a little if needed. One of the difficult parts was keeping parts at 90-degree angles because the beam that I tacked on often pulled it to an acute angle, so I had to pull it back to a right angle afterward. With all of the parts tacked together, I started welding the joints. After a long process of welding, I grinded the joints to make them smooth.

With the frame of the go-kart finished, I moved on to assembling the parts. I started off with the rear axle, this is where the gears and brakes will go. For mounting the axle, I will be using 4 axle bearing kits. I put the axle through the bearings before welding them onto the frame to ensure the bearings will line up.

Bearing kit

Assembeled Bearing

After the rear axle bearings were installed, I then installed the steering brackets and spindles. This was a little more difficult than the bearings because there is no axle to ensure that they are in the correct position, the steering spindle bracket must be straight and symmetrical so that there won't be steering issues in the future. To make this process easier, I started off by just attaching the spindle bracket with one tack. I then used a bubble level and gradually bent it till it was straight. After I have the bearings and spindle bracket attached, I started adding support to make sure they won't bend when driving on uneven terrains.

Feiyu Wu
12/11/2021


With the rear axle and steering system ready, I mounted on the wheels and rolled it off the table for mounting the engine. Originally I was thinking of using the crane that was in the shop to lift the engine up and drop it into the frame but the crane was blocked and unavailable for use. Instead, I used the forklift to lift the go-kart frame up and dropped it onto the engine. And then I lifted the engine up from the inside to have easier access to working on it. To do so, I first tied a rope through the lifting hooks on the engine, then hung the rope onto a long metal bar. With the help of a fork lifter, I was able to lift up the metal bar, therefore also lifting the engine up. I first started by mounting 3 bars across the back and welding the motor mount onto the bars. Then I slowly dropped the engine onto the motor mount and adjusted it until the holes lined up. Bolted it together but not tightly so that I can move it forward and back when adjusting the tension of the chain. After the engine was secure, I continued with mounting the torque convertor.


At this point, the only things left to do until I could test run the go-kart is attaching the fuel tank onto the frame and connecting the fuel line, and connecting the battery. I first grinded off some of the paint on the gas tanks so that I could weld it onto the frame. I made sure that the gas tank was a little bit above the engine, allowing easier fuel flow. Then I used a battery tray and attached it behind the engine. For the first test, I used a jack stand to lift the rear up, enough for the wheels to spin freely. I made sure the gas cable and brakes work before actually driving it on the road.

Feiyu Wu
12/11/2021

A


Feiyu Wu
12/11/2021

Bibliography:

"Are Go-Karts Street Legal? Go-Kart Laws in All States Compared." GoKartGuide, January 10, 2021. https://www.gokartguide.com/go-kart-laws/#:~:text=LSVs%20are%20required%20to%20be,registered%20with%20a%20valid%20insurance.

Echt, Albert, et al. "Go-Kart Torque Converter vs Clutch: What's Better?" GoKartGuide, 10 Jan. 2021, https://www.gokartguide.com/torque-converter-vs-clutch/.

"Go-Kart Gear Ratio Chart and Speed Calculator." GoKartGuide, 10 Aug. 2021, https://www.gokartguide.com/gear-ratio-chart-speed-calculator/.

"How to Build a Roll Cage - Ultimate Roll Cage Design Guide." Rogue Fabrication, September 14, 2021. https://www.roguefab.com/building-roll-cage/.

The Mechanic Doctor. "How to Build a Roll Cage - Everything You Need to Know." The Mechanic Doctor, January 7, 2020. https://www.themechanicdoctor.com/how-build-roll-cage/.

"The Ultimate Go-Kart Chain Size Chart." GoKartGuide, 10 Jan. 2021, https://www.gokartguide.com/go-kart-chain-size-chart/.

Wolf, Andrew. "Building Your First Roll Cage: What You Should Know." Chevy Hardcore, May 8, 2018. https://www.chevyhardcore.com/features/building-your-first-roll-cage-what-you-should-know/.

10 Things to Know about a Go Kart Centrifugal Clutch, https://www.bmikarts.com/10-Things-about-Centrifugal-Clutch.