Team CLC

Preble High School
2010-2011

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Meet the Team

Team CLC consists of two groups each containing 4 members. The first group is third hour and the second group is sixth hour. Philip Witte (junior), Aaron Figgins (senior), Lizzy Lovering (junior), and Eric Torbenson (senior) make up third hour.

Philip Witte

Philip has taken IED and AED, an advanced engineering course at Preble High School.

Aaron Figgins

Aaron has taken IED and Intro to Technology at Preble. Aaron also has experience welding.

Lizzy Lovering

Lizzy has taken IED and AED, an advanced engineering course at Preble High School.

Eric Torbenson

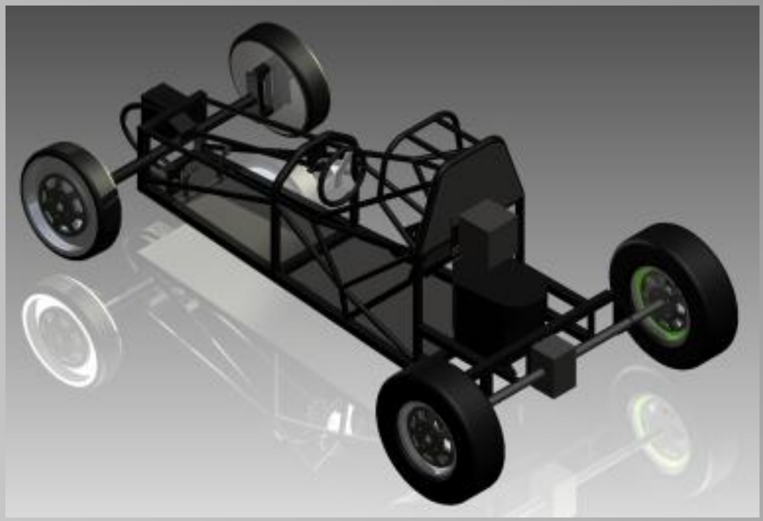
Eric has also completed IED and AED, an advanced engineering course at Preble High School and a semester of welding.

About Formula High School

Created by Mr. Meyer, Formula High School is an equal opportunity program that was created to “allow students who are interested in motorsports, engineering, and technology areas a realistic outlet to showcase their skills and talents” according to Formula High School’s official website. In other words, this program gives students a chance to excel and build their talents in a more professional atmosphere outside the classroom. We compete against other teams in our school, along with teams from other schools across the Midwest. The schools compete in time trial race, to see which car had the best design. At first glance, the cars look very similar. This is because of the safety guidelines placed on the construction of the vehicles. Although they may look similar, there are many parts of the car designs from scratch by each team for their given vehicle. Differences in the back end design, alignment, drive trains and steering mounts gives the cars hope to come out on top on race day. Because of the fact that students have to find companies to sponsor there vehicle, it gives students a glimpse at how the business world works. Formula High School aims to show students the possibilities out there for careers in the engineering field, along with connect students with manufacturers to make those possibilities into realities. Working in a team environment aloes the students to refine and shape their problem solving skills and see the importance of keeping to a plan, and reaching deadlines. This program gives students real world experience in problem solving, and team work.

Design Process

Our goal from the beginning of the year has and always will be creating a unique car that can give better performance than the other teams. One problem every car faces is the balance of weight in the car. The engine is mounted in the back of the car, creating extra weight in the back then in the front. To try to balance the weight difference we have designed our car with the battery in the front rather than in the back. This idea is unique to our team and theoretically will give better performance than the other teams. All of the teams were given a choice to include a fixed differential or a Hilliard differential. Our team decided to go with a Hilliard differential



because it allows one tire to spin faster than the other tire while taking turns. This advantage will allow us to take turns faster, giving us a cutting edge come race day. Due to the change of differentials we also had to buy a new engine. The previous engine supplied to us was a horizontal shaft engine. This engine would have not worked with our differential so we needed to buy a vertical shaft engine. Although the main part of the chassis was already designed for us on Autodesk Inventor, there have been several aspects of the car that we have had to design from scratch. An example includes the back end of our car where we will mount our engine and gear box. Another aspect of the car was a new seat. The previous seat was very heavy, so we designed a light-weight seat that will reduce the car's weight. A safety feature we had to design was a firewall that we would place between the driver and the engine. Using the sheet metal feature in Autodesk Inventor, we were able to design an effective firewall that provided the protection needed. Our team also designed a new lightweight pedal system. Our goal in designing the pedal system was to make it as lightweight and simplistic as we could. Our result was a very small pedal system. Despite the doubts of other teams, the pedal system preformed great on race day.

Parts List

Part Description	Manufacturer	Model Number	Price	Qty	Cost
Master Cylinder Assembly	California Import Parts	VWC-113-611-015-BH	$39.95	1	$39.95
Brake Fluid Reservoir	California Import Parts	VWC-113-611-301-L	$5.50	1	$5.50
Thrust Washer	California Import Parts	VWC-111-405-661	$1.75	2	$3.50
Ball Joint Eccentric	California Import Parts	VWC-131-498-319	$28.45	1	$28.45
Clamp Nut – Left	California Import Parts	VWC-131-405-669	$5.50	1	$5.50
Clamp Nut - Right	California Import Parts	VWC-131-405-670	$5.50	1	$5.50
Upper Ball Joint	California Import Parts	VWC-131-405-361-F	$12.95	2	$25.90
Lower Ball Joint	California Import Parts	VWC-131-405-371-G	$12.95	2	$25.90
Disk Brake Conversion Kit Blank Rotors	California Import Parts	ACC-C10-4121	$339.95	1	$339.95
Disk Brake Caliper Used for real axle	California Import Parts	C13-98-1150-B	$64.95	1	$64.95
Front Brake Rubber Hose	California Import Parts	VWC-311-611-701-B	$9.45	4	$37.80
Dust Cap	California Import Parts	VWC-111-405-692-B	$2.75	2	$5.50
U-Joint for Rack and Pinion	California Import Parts	C26-425-160	$24.95	1	$24.95
Splined Shaft for U-Joint	California Import Parts	C26-425-164	$8.50	1	$8.50
Universal Chrome Steering Shaft	California Import Parts	C26-425-011	$32.95	1	$32.95
Chrome Steering Bearing	California Import Parts	C26-425-013	$12.95	1	$12.95
14” Rack and Pinion	California Import Parts	C26-425-150	$99.95	1	$99.95
Quick Release Steering Wheel Hub	California Import Parts	C26-415-100	$16.95	1	$16.95
Brake Hub for 1 ¼” Axle	BMI Karts	600253	$15.00	1	$15.00
Sprocket Hub for 1 ¼” Axle	BMI Karts	600243	$28.95	1	$28.95
35 Series RLV Extreme Chain	BMI Karts	400635GG	$14.95	1	$14.95
Steering Wheel 10” DIA	BMI Karts	410200	$21.99	1	$21.99
1 ¼” Tubular Steel Axle Bearing Mount Kit	BMI Karts	400415	$24.95	2	$49.90
44” 1 ¼”” Tubular Chrome Moly Axle	BMI Karts	601444	$43.50	1	$43.50
13 x 6 Steel Wheels 2.5” BS 4 holes on 4” BC	Bassett Racing Wheels		$57.00	4	$228.00
Sumitomo HTR 200 175/50-13	Tire Rack		$48.00	2	$96.00
Sumitomo HTR 200 205/60-	Tire Rack		$56.00	2	$112.00

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Formula High School Fiberglass Body Shell	Fiberglass Solutions		$350.00	1	$350.00
Azusa Split Sprocket 89-97 tooth, 35 series	Reiken’s Racing	AZ-2699-XX	$35.06	1	$35.06
NORAM Enforcer Clutch 12 tooth, 35 series chain	Reiken’s Racing	NAENF12	$206.44	1	$206.44
16 HP Briggs & Stratton Vertical Shaft V-twin engine	Preble Motorsports		$0.00	1	$0.00
Pre-Bent Roll Bars	Preble Motorsports		$45.00	1	$45.00
1 1/2" Square Tubing 14 ga 20 feet	SI Metals		$1.47	20	$29.40
1" Round Tubing 14 ga 60 feet	SI Metals		$1.19	60	$71.40
RCI Aluminum Fuel Cell	Summit Racing	RCI-2010A	$95.95	1	$95.95
R.J.S. Racing 5 Way Harness	Summit Racing	50502-18-23	$69.95	1	$69.95
Drive Hub 1 ¼” Axle 4 on 4” BC	Jegs.com	056-9030	$25.99	2	$51.98
Two Piece Shaft Collars	McMaster Carr	6436K21	$5.01	4	$20.04
Threaded Tube Inserts 3/8-24 RIGHT HAND	McMaster Carr	94640A115	$5.04	2	$10.08
Threaded Tube Inserts 3/8-24 LEFT HAND	McMaster Carr	94640A119	$5.04	2	$10.08
Rod End 3/8-24 RIGHT HAND	McMaster Carr	2458K141	$5.39	2	$10.78
Rod End 3/8-24 LEFT HAND	McMaster Carr	2458K142	$5.39	2	$10.78
Round Base Weld Nut 1/4-20	McMaster Carr	90596A029	$5.84	1	$5.84
Axle Snap Rings	McMaster Carr	97633A340	$5.62	1	$5.62
Female Pipe Elbow 1/4 Hose to 1/4 NPT	McMaster Carr	5346K122	$7.42	1	$7.42
Stainless Steel Socket Head Bolts	McMaster Carr	92949A542	$9.15	1	$9.15
Stainless Steel Bonded Washers	McMaster Carr	94709A416	$14.56	1	$14.56
#8 AN Aluminum Cap	ANPLUMBING.com	992908	$3.49	1	$3.49
#8 AN to 1/4" NPT Adapter	ANPLUMBING.com	916107	$8.48	2	$16.96
Wheel Stud	NAPA	BK 641-1632	$1.99	8	$15.92
Battery Switch	NAPA	NW 785121	$26.99	2	$53.98
Fuse Holder	NAPA	BK 7825334	$2.29	1	$2.29
Oil Filter - NAPA Gold (WIX)	NAPA	7035	$0.00	1	$0.00
Starter Button	NAPA	ECH STB6301	$9.66	1	$9.99
					$2,557.10

Construction

After a week of designing the chassis on Autodesk Inventor we were eager to get into the shop and start construction. We first laid out the bottom of the chassis and welded the roll bars and floor frame together. We then made the support bars that would connect it all together along with the halo shortly after. The floor was cut out by the water jet at NWTC and welded onto the bottom of the chassis. The steering column was then mounted shortly after. Our battery mount, master cylinder, and nose cone housing is unique compared to the other cars but we hope that it will be a lot more efficient. The pedals were designed on Inventor and cut on the water jet at NWTC. After the differential came through the mail we were able to design the back end taking into consideration the positioning of both the engine and the differential. The back end then was assembled and welded on the car. The differential was mounted the same day. The seat that was used last year was heavy and bulky so we redesigned ours out of 1/8 inch aluminum sheet metal. Once the seat was in place we had to install a firewall. Using our design from Autodesk Inventor, we cut and bent an aluminum sheet. Once the firewall was manufactured we installed it to the chassis.

Once the chassis was completed we could start working on the front end. We started the front end with the front axle. First the front axle was cut to length and then we cut two indents in the axle to fit it to our frame. We cut both ends of the front axle at a 5 degree angle and welded the front spindle mounts on to our axle. We then mounted the front tires to the axle. We created a battery mount using steel so we could mount the battery box in the front of our car. After the pedal system was designed, we cut out the parts at NWTC we assembled the pedal system to our car. Once the pedal system was installed we mounted the master cylinder to the front end and the brake pedal. We also had to attach a throttle cable to the gas pedal.

After the designs for the back end was finalized we started cutting the parts needed. We then welded together the back end frame and welded it to the chassis. Using the water jet at NWTC, we cut out the engine mount plate. After the engine mount plate was cut, we welded bolts to the back end so we could slide the engine mount plate to reposition the engine easily. Once the engine was mounted in the back end we could mount our rear differential. We then created two sprockets and attached the chain to our engine.

Formula High School Rules

All Formula High School vehicles are to be completed before all track events.
Absolutely NO fabrication will be allowed at the track events.
FHS officials reserve the right to disqualify a team if the officials believe there is a safety hazard present on the team's vehicle.

Overall Sizes:
Wheelbase: 81" – 87" measured from center of front spindle axle to center of rear axle.
Width: 50" to 58" measured to the outside edge of the mounted tire.
Max Overall Length: 144" including body shell.
Ground Clearance: 2" MIN – 6" MAX
Vehicles not within these measurements will not be allowed to compete, even as an exhibition. Vehicle widths and wheelbases are set to ensure a safe and stable vehicle for the track day events. Specifications must be followed. **There will be no exceptions.**
Chassis: All teams must use the supplied chassis model as the base for their vehicle. Chassis MUST be constructed to the chassis model within 1" of specifications. All frame members shown on the model must be present in the completed chassis.
Roll Bar Tubing: 1 ½" round mild steel tubing, 0.083" (14ga) wall thickness. Roll bar tubing must be a single continuous piece. NO SPLICING ALLOWED. Driver's helmet should not be excessively forward of the roll bar protection when seated in the vehicle.
Bracing: 1" round mild steel tubing, 0.083" (14ga) wall thickness.
Floor: 0.0747" (14ga) mild steel sheet, stitch welded to the bottom frame rails. The minimum weld stitch pitch should be no more than 1-3.
Body Shell: Teams must use an approved FHS fiberglass body shell. If a team chooses to use an alternate body shell, that team must submit approval directly to FHS officials. The only approved body shell materials are: fiberglass, Kevlar, carbon fiber or 0.032" aluminum sheet. Aluminum must either be polished or painted.
Appearance: All FHS vehicles must be painted, gel coated, or powder coated with school and sponsor decals appropriately placed. Bare metal frames will not be allowed.
Mandatory Decal List (List may change at later date):

- Sugar Grove Custom Cars
- Fiberglass Solutions
- Road America
- Briggs & Stratton

Decals must be placed in a position where they are easily seen from both sides of the car. FHS officials reserve the right to add to the mandatory decal list at any time.
Firewall: .032" or thicker aluminum or mild steel sheet must be used for a firewall between the driver and the engine compartment. Teams must try to make all reasonable efforts to fully seal the driver's compartment from the engine compartment. Teams should try to keep all gaps to less than ½".

Safety Harness: All teams must use a 5-point safety harness, installed to safety harness manufacturer's specifications. Harnesses certification stickers must be within five years of event date.

Engine: Briggs & Stratton 16 HP Vanguard V-twin ONLY. To further clarify, we are accepting engines in the 3034xx and 305xx (horizontal) and the 3037xx and 3057xx (vertical) model line. Provided the engine is designated as a 30 cubic inch, OHV, "V-twin" engine that is rated at 16hp, and falls in the range listed above, it will be accepted. No other engine will be allowed. NO power adders or modifications to the engine allowed, except for wiring extensions, throttle and choke connections. Engine must have a throttle return spring attached directly to the throttle shaft arm. Governor may be removed/disconnected. See suggestions in regards to RPM limit. Teams have asked if they can use an engine other than the recommended Briggs & Stratton. The reasons why there is only one approved engine manufacturer:

Eliminates the need to use restrictor plates to equalize engine power levels.
Common parts which allows teams to help each other out at the track.
Limited availability of appropriate sized and capable engines from other manufacturers.
Simplifies the inspections process for track officials.

Kill Switch: Two paddle type kill switches are required. One switch shall be located in easy reach of the driver and labeled appropriately. The second switch shall be located on the left side of the rear roll bar but above the body shell. This location is shown on the chassis model. The switch will be marked with a red vinyl or painted 3" equilateral triangle and labeled ON/OFF with .25" high contrasting color text. Both switches must be demonstrated to effectively shut off the engine.

Fuel system: Teams may relocate the stock Briggs and Stratton vacuum fuel pump to allow proper fuel supply to the pump. NO electric fuel pumps. Fuel tanks/cells must be commercially available, designed for fuel use and installed to manufacturers specifications.

Exhaust: Exhaust outlet(s) must extend past the body shell by a minimum of 1".

Transmission: Centrifugal clutch with a single overall gear ratio. No CVT or multiple gear transmissions allowed.

Overall Gear Ratio: Open. Teams are allowed to gear for various track configurations.

Tires: DOT rated tires. No racing slicks or trailer tires allowed.

Overall tire diameter: 24" maximum

Suggested tires sizes: Front: 175/50-13 Rear: 205/60-13

Rim: 13 x 6 steel rim, 2.5" back spacing suggested

Front Spindles: All teams must use standard VW Beetle spindles, ball joints, eccentric adjusters, rotors and disk brake calipers. No modifications allowed to these parts.

Rear Brake: All teams must utilize a standard VW Beetle brake caliper, actuating a single brake rotor keyed or splined to the rear axle. At least one rear tire must transmit braking power to the ground. This caliper will also be on a separate hydraulic circuit from the front brakes.

Suspension:

All teams must have a minimum of 1 successful year of FHS experience before they may incorporate an IFS/IRS suspension.

Teams designing/building and IFS/IRS system must incorporate production spindles, brakes and uprights.

Teams must supply engineering drawings and or pictures of their design to FHS officials for approval before manufacturing their system.

Minimum Rear Axle Diameter: 1 ¼”
Steering: Rack and Pinion ONLY, no go-kart steering allowed.
Steering Wheel: Steering wheel must be either a continuous round or “D” shaped wheel. No butterfly style steering wheels allowed.
Minimum Tie Rod Diameter: ¾”
Driver Safety: All drivers must use the following safety equipment:

DOT or Snell rated full-face helmet, manufactured within 5 years of event date
Neck collar
Closed toe shoes
Long pants
Long sleeve shirt/jacket
Gloves
Impact rated eye protection, minimum rating of Z87.

No sweats pants or windbreaker pants allowed.
Safety Glasses: All team members must be wearing safety glasses when actively participating in repair or adjustments to the team vehicle.
Overall Rule of Conduct: Students must present themselves in a professional manner. Teams will be disqualified and removed from the track in any team member does not follow directions from the officials.
SUGGESTIONS:
Rear axle bearings should be placed as close to the inner side of the wheel hub as possible to limit axle bending/twisting. Some teams have run up to a total of four bearings across the rear axle.
Chrome Moly Steel axles suggested. Low quality axles have bent under load.
Gear ratios: A good rule of thumb is to start with an overall gear ratio of 8:1 and then gear for the existing track conditions and individual vehicle response.
Chain tensioning devices: Use a sliding engine base set-up to adjust chain tension. There was a much higher incidence of thrown chains when using idler sprocket assemblies.
Install shaft collars on both sides of the rear hub assemblies. This is extra insurance to keep the hubs in place on the axle.
Fasteners: Teams should try to use at least grade 5 or higher fasteners, with nylock nuts, when possible.
Standard Formula High School wheel bolt pattern: 4 on 4”B.C., 2.5” back spacing.
Exhaust: Teams have run both open pipes and mufflers. The engines seem to work the best with some type of muffler. Individual team chassis dyno testing is suggested.
RPM: Engines should be limited to 4500 RPM. Teams run a risk a valve float about that RPM.
NORAM Enforcer clutches have shown a much higher durability than the NORAM Mini-Cup clutch.
When using a NORAM Enforcer clutch, install a spacer behind the clutch to eliminate the chance of the clutch sliding towards the engine.
Use Loc-tite on the crankshaft bolt. This reduces the chance the bolt will come out, dropping the clutch on the track.

Problem Solving

Problem Solving is a big part of the learning experience in this class. There were several different types of problem solving that took place involving: construction, communication, design, and fixing problem on race day.

One of team CLC’s biggest problem was we initially had with the construction, was cut the front axle to long. After we welded the front axle to our frame, we realized that the axle was 4” too long and we were out of spec. In order to put our axle back into spec we needed to cut 2” off each side of the axle. Once it was cut, we hand-grinded the ends to 5° and welded new front spindle mounts. Other problems arose from mistakes that were made by the team, forcing us to think outside the box to come up with a solution furthering our learning experience. Such mistakes included dropping a bolt in the engine and having to take it apart to find it, learning the difference between metric and standard threads, and learning to figure out exactly what the team from the other hour had done the previous day to pick up where they left off. There were many other small mishaps that were readily and easily fixed within the day.

In the area of communication there were several problems between our hour and the other hour that we learned to rectify. With the difficulties of understanding the progress they made in the lab and continuing their progress, as well as attempting to rectify their mistakes and not putting them on the defense when we explain our ideas on improvements and vi-versa. To improve our communication we started a daily log that we would track of our progress and we could ask each other questions on what was to be done or what we requested the others to do during their hour. This proved to be very effective and worked well for everyone in both hours.

We found that some of our designs didn’t correspond to what we actually needed. An example of this is our decided to use a horizontal shaft verses a vertical shaft; we had to alter the design of the back end. At first it seem to work fine, but after looking into the materials, we found there would be more light weight materials to use that would be beneficial to the car overall.

After all the hard work and problem solving in the class, it was time to see how the vehicle would perform. Once on the track and racing for a while, some problems rose to the surface. One of the very first dilemmas that we ran into was difficulties getting the engine to start. After several minutes of analysis it was discovered that the choke wasn’t in the casing properly so when it was pulled, just the casing would move and the actual cable was staying lack. After identifying the problem, it was relatively easy to rectify the situation with pliers. Another issue we had was a problem with our breaks. First we found a slight leak when we took it back off the truck, so we bled them again and tightened everything, but then the bushing broke which we replaced with a bunch of washers. After that was fixed they worked for a while, but later they started slipping again towards the end of the day. Once we got it back to the shop to check them they worked just fine, so our thing was, the brake fluid just got to warm. Thankfully all our problems we fixable and a great learning experience for all.

Sponsors

Canadeo - 2621 MARY JO CT
Green Bay, WI 54311

Briggs and Stratton - Briggs & Stratton Corporate Headquarters
P.O. Box 702 Milwaukee, WI, 53201

RCi- 12001 C.R. 1114 Tyler, Texas 75709

R.J.S Racing Equipment, Inc.- RJS Racing Equipment, Inc.
23506 N. John R. Road
Hazel Park, MI 48030

R.J.S Racing Equipment, Inc.- RJS Racing Equipment, Inc.
23506 N. John R. Road
Hazel Park, MI 48030

Fiberglass solutions- 1933 Cofrin Drive Green Bay, WI 54302

Hilliard- The Hilliard Corporation
100 West Fourth Street
Elmira, NY 14902-1504

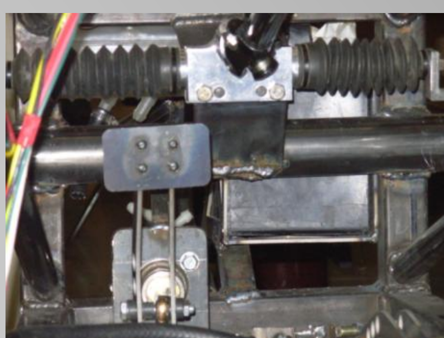
Centerline Machining and Grinding, Inc. - 760 Centerline Drive | Hobart, WI 54155

Cape Financial Group of Stifel Nichols - 200 S. Washington Street
Third Floor
Green Bay, WI 54301

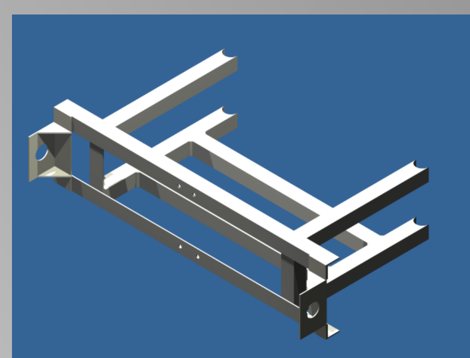
Pictures

Sean welding the chassis

This is the almost finished chassis for our car, just a few weeks out. The halo is in progress



The beginning of our pedal and steering system



The Basic design of the back end, designed by the team

We are fitting the seat, and installing the steering. We recently finished constructing the back end.

Aaron Figgins racing our car at the Briggs & Stratton motor complex.

Our joint team on Track Day