## Intro

This year is Iron Reign's eleventh season in FIRST, our ninth year overall. We've participated in five years of FLL and seven years of FTC:

FLL

- Body Forward
- Food Factor
- Senior Solution
- Nature's Fury
- World Class

FTC

- Ring It Up!
- Block Party
- Cascade Effect
- RES-Q
- Velocity Vortex
- Relic Recovery
- Rover Ruckus

While our team originated at WB Travis Vanguard and Academy, as our members became older (such is the passage of time), we moved to the School of Science and Engineering at Townview (SEM) in DISD. Despite our school being 66% economically disadvantaged and being Title 1, our school consistently ranks in the top 10 nationwide academically. Our school also has numerous other award-winning extracurricular clubs; including CX Debate, Math/Science UIL, and more. Our school employs a rigorous STEM-based curriculum, which provides our students access to specialized class schedules, such as Engineering, Computer Science, and Math, as well as paying for AP classes that our students would normally not be able to afford. The average SEM student takes at least 10 APs.

## A History of Iron Reign

Iron Reign has been a team for nine years. We initially started as a First Lego League (FLL) team, plateauing in regionals every year we competed. This was usually not due to the actual "robot game" in FLL, but because of our presentations. Starting there, Iron Reign was defined as focusing on creative and innovative designs. We also did Google's Lunar X Prize program every summer, achieving finalist status in 2011 and 2012. Upon moving to high school, we started doing FTC, as FRC was too cost-prohibitive to be parent-run.

We have been an FTC team for 7 years, advancing further and further each year. In Velocity Vortex, we got to the South Super Regionals, qualifying by winning the North Texas Inspire Award, which means that we represent all parts of the competition, from teamwork, to the presentation, to creativity, and to the actual game. In Georgia, the same year, we were the first alternative for Worlds if another team dropped out.

Then, last year, we finally got to Worlds. We got there in two ways: the 2nd place Innovate award at Supers, and also got the lottery, on the prior merits of being a FIRST team for so long. There, we got the recognition that we'd been seeking – we won the Worlds Motivate Award.

In the same vein, we compete in the Texas UIL State Championships. For those unfamiliar with UIL, it is the main organizational committee for all public school academic and athletic events in

the state of Texas. Through UIL, we helped compete in the first test program for the UIL Robotics program and since then have competed in every subsequent tournament. This year, it finally got out of the trial period, and became a full-fledged competition.

## Outreach

Our outreach stands out from other teams through our mode of presentation. Last year, we renovated a 90's Seaview Skyline RV, took out the "home" components, such as the bathroom and bedroom, and turned it into a mobile tech lab, so that we can bring STEM to underprivileged demographics within our community. Our RV currently holds 4 3D Printers, 30+ computers, 3 widescreen TVs, and 1 microwave. Our current curriculum consists of teaching kids 3D modelling in the back of the RV, using Google Sketchup, as it is free and available to any family with a computer. We usually help them design keychains, as they are memorable, but don't take excessive time to print on our printers. In the front, we teach kids how to use EV3 robots and teach them how to use the EV3 programming language to compete in a sumo-bot competition. We also give advice to parents and educators on how to start FIRST teams.

To make Iron Reign's history entirely clear, we **built** the RV two years ago. We do not claim any credit for the actual construction of the RV in this journal; however, we do share the goals of this program: making the RV run as a standalone program, expanding the program to other communities, and serving more and more underprivileged communities in Dallas. To our own standards, we have achieved this.

Our current funding services for the operation of the RV come from Best Buy, who purchased the thirty-plus laptops and four 3D printers. We receive grants from non-profits such as BigThought and Dallas City of Learning to fund events and provide staff (even though our team provides staffing).

This year, we have obtained $150k in additional funds to expand our outreach program by building a second Mobile Learning Lab. This is an unprecedented level of funding - it can cover the majority of buying an RV, staffing it, and filling it to the brim with technology. So far, this is the highlight of the Iron Reign season.

When not in outreach service, we can transform our RV into tournament mode. We have taken numerous long-distance road trips aboard our RV, with locations such as Austin, Arkansas, Oklahoma, and Florida. We substitute the laptops for a band saw and drill press, use the flat screens to program instead of teach, and bring our higher-quality personal 3D printer. At tournaments, we encourage other teams to board our RV, not only to encourage them to start their own similar programs, but also to help them with mechanical and building issues.
Iron Reign spends a lot of time on outreach. So far, we've spent 84.5 man-hours and talked to just under 2000 people (1995) within our community. Our goal of this outreach is to reach disadvantaged children who would not normally have the opportunity to participate in STEM

programs in order to spark their interest in STEM for future learning. Some of our major outreach events this year include Love Field Turn Up!, where we reached 1100 children from around the Metroplex. We've worked for our school district in various circumstances, including bringing children back-to-school STEM education and running orientations for our high school. We also represent FIRST in a variety of ways. At our Mobile Learning Lab events, we talk to parents and educators about starting their own FLL and FTC teams. We currently mentor our school's FRC team Robobusters and are in the process of founding another. We are the mentors for our sister team, FTC 3734 We also provide help as-requested for FLL teams to go back to our roots. As well, we've historically hosted underfunded teams for late-night-before-tournament workshops.

| Date | Event | People | Hours | # People |
|---|---|---|---|---|
| 2018-04-26 | SEM Orientation | Shaggy | 6 | 200 |
| 2018-06-23 | Turn Up! Dallas Love Field | Justin, Ethan, Charlotte, Kenna, Abhi, Evan | 24 | 1100 |
| 2018-07-14 | Dallas Public Library | Ethan, Kenna, Charlotte, Evan | 16 | 190 |
| 2018-07-21 | MoonDay | Karina, Ethan, Janavi, Charlotte | 26 | 200 |
| 2018-07-22 | Summer Chassis | Kenna, Ethan, Charlotte, Karina, Shaggy, Abhi | 24 | 25 |
| 2018-08-01 | SEM Summer Camp | Arjun | 6 | 175 |
| 2018-08-18 | Back to School Fair | Ethan, Kenna | 6.5 | 130 |
| 2018-10-13 | SEM STEM Spark | Ethan, Charlotte, Janavi, Abhi, Karina, Justin | 80 | 140 |
| 2018-10-16 | Travis High School Night | Ethan, Evan, Kenna, Charlotte, Karina | 12.5 | 120 |
| | | | 201 | 2280 |

## Business and Funding

Iron Reign, for the past two years, has increasingly ramped up its funding. We aggressively seek out new sponsors so that we can continue to keep Iron Reign great. Currently, these include:

- BigThought - RV materials, staffing, and upkeep
- Dallas City of Learning (DCOL) – RV materials and upkeep
- Best Buy – 4x3D Printers, Laptops for RV
- DISD STEM – Practice field and tournament funding
- RoboRealm - $1500 of machine vision software

- Dallas Makerspace – Access to machining tools
- DPRG – Robot assistance
- Mark Cuban - $2500
- DEKA - Rookie team funding for our two new teams
- Texas Workforce Commission - $525 for our team, $2350 for new ones

We are always seeking more funding. We apply for the FIRST and FIRST in Texas grants every year, and seek grants from STEM-curious companies and individuals in the Dallas area. We have applied for grants from Orix and Mark Cuban, receiving personal funding from the latter. We receive staffing and upkeep from a local Dallas non-profit, BigThought. Currently, we are seeking funding and assistance from Ernst and Young, an international company with a Dallas branch, that a team member works for.

In previous years, we have lacked the ability to get significant transportation funding to get to tournaments. However, through our partnership with DISD, we have solved that problem, and when DISD is unable to provide transportation due to short notice, we can provide our own transportation due to our building of the RV.

## Reference Business Letter

*"To whomever it may concern,*

*My name is Abhijit Bhattaru, and I am currently a member of Iron Reign Robotics at the School of Science and Engineering at Townview, a DISD magnet school whose population is 66% economically disadvantaged. We have been a FIRST team for about nine years, over half of some of our members' lives. For the past six years, we have operated as FTC Team 6832, Iron Reign. We've achieved various forms of success in these years, culminating with our rise to the Houston World Championship this year, winning the Motivate Award, an award for outstanding outreach within our community.*

*What makes our team stand out from other teams is our dedication to our community. Two years ago, we converted a Sea View RV into a Mobile Learning Lab equipped with 4 3D printers, 15 EV3 robots, and 30 laptops to teach children basic programming and 3D modelling. The purpose of all of this is to start a spark of STEM in underserved communities so that these children can later go into STEM. And, we have expanded this program nationwide, presenting at the National Science Teachers' Association national conference in 2017. We have partnered with local nonprofits such as Big Thought to fund our outreach expenses, and to reach out to interested communities across Dallas, and the nation, to expand our program.*

*So, why do we need your help? Our school is 66% economically disadvantaged, and adding to that, DISD is facing up to an $81 million budget gap. The district's funding for robotics has been dropping to the point where only the basics are covered and even then come too late*

*in the season due to red-tape. The one silver lining is that the DISD STEM Department is still able to handle most of our competition travel expenses. This offsets our largest expense category. But we still have to fund the development of our robot, and we aim high. Our robot earned an Innovation Award at the twelve-state South Super Regional Championship this year. We try to push the boundaries of design and execution and this requires a different level of funding for parts, materials and tools.*

*To achieve this higher level of funding, Iron Reign is aiming to create a 501(c)(3) foundation to avoid the level of red tape and financial mismanagement from DISD that we have experienced for the past several years. This is where you come in, Mr. Cuban. We are asking for a seed donation for this non-profit, so that our team can become a free-standing team unhampered by DISD's bureaucracy. Our mission would still be to serve our school and community, as it has been for the past eight years, but we would be able to avoid DISD's mismanagement.*

*If the money is not utilized for a seed donation, we would allocate it for new robot parts and equipment. A starter kit for FTC is at least $600 but this is nowhere close to cost of a World Championship robot. To become more successful in the robot game for the following seasons, we would need a higher investment into parts, considering many things can go wrong in an 8 month season. Your donation to the cause would allow us to become more successful.*

*In return for your investment, Iron Reign will set out to accomplish what you desire from us. We can promote you and your companies on our website, presentations, etc. However, this is just one option. We are open to helping you in whatever way you would like in return for your help to our team.*

*Thank you for taking the time to consider our request, and if you happen to have additional time, we would like you to look over our previous Engineering Journals here to see our team's engineering process and history. To see a video about our robot, please visit https://www.youtube.com/watch?v=TBlGXSf_-8A.*

*Also, since you were not able to meet with us, we thought we would bring ourselves to you. Here is a video of our team and the FIRST Tech Challenge program.*

*Thanks for your consideration,*
*Iron Reign (6832)''*

## Looking Back, Moving Forward

Recently, Iron Reign has put a large emphasis on recruitment. We have alternating years with high turnover due to graduation, so we hold recruitment meetings at our school every year for both Iron Reign and Imperial Robotics.

We already have another team in our school, team 3734 Imperial Robotics. **3734 is an entirely different team, with different sponsors, members, robots, journal, outreach, and codebase.** That being said, we recruit the more accomplished members of that team. The teams' relationship is most similar to the difference between a Junior Varsity team and a Varsity team.

We tend to recruit based on robotics experience, but having robotics experience alone is not a guarantee of joining our team. Iron Reign has a specific culture, and we tend to recruit people whose personalities fit our culture. We also do not accept people who only want to join robotics as a resume booster. While robotics is indeed a resume booster, and we allow every member to claim co-captain on their college applications, members of Iron Reign ought to join out of their genuine passion for robotics, not because of it getting them ahead in the rat race of college applications.

This year has been an unprecedented year in recruitment for Iron Reign. We recruited approximately 30 new freshmen, expanding the Iron Reign program from two teams to four; from Iron Reign and Imperial Robotics, to adding Iron Star Robotics and Iron Core. And, our efforts have been recognized by our donors: we have been supplied four additional REV kits, and two fields so that we can support the larger program.

## Build

Iron Reign utilizes a variety of parts and kits. At the moment, Iron Reign prefers the REV kit due to its simplicity - everything seems to just fit together, while still being minimalist. However, Iron Reign's old standby is 3D printing. We've used 3D printing before it became widespread within FTC, and we've become sort of pros at specialized design. We even have our own 3D-print kits such as REVolution, a system to turn REV extrusions into axles.

This year, we're using a new base that's more adapted to the challenge. Its working name is Minichassis. It is approximately 6"x6" for the base with an additional 4" extension for mounting. It uses four 4" AndyMark mecanum mounted low to the ground with NeverRest 20s with planetary gearboxes attached to each wheel. So, the robot is astoundingly small and fast.

We have two main attachments to our robot, the lift and the intake. First, the intake is a small square with silicone oven mitts attached to it. It knocks the particles upward into racks spaced 68mm apart. This spacing allows the blocks to fall through while the balls move upwards into the lift. Then, the lift. The lift is a series of REV rails attached through a linear slide kit with a hook and particle holder on the end. This extends, allowing the robot to deposit particles in the lander while also being able to hook onto the lander.

In addition to this design, we have also developed BigWheel, aptly named for its 6-inch wheels at the back with a front-facing omniwheel. At the front of the robot, we installed two “arms” which brace an intake system named “CornCob” for its lumpy, cylindrical appearance. This is mounted at a height just so it only contacts the silver particles, not the gold. But, what truly differentiates this robot is it’s lift mechanism. Unlike the majority of FTC robots we’ve encountered this year, BigWheel has no lift, extending-arm, or linear slide. Instead, we have a central lever mounted to two high-torque motors, with a ridiculous 3:1 gear ratio for a cumulative 19.4 N*m of torque. This serves to rotate the robot into a near-total-vertical position, allowing the arms of the robot to reach to the lip of the lander. We feel that this differentiates our team’s robot from the majority of other robots within the current FTC season.

## Code

Iron Reign has a large pre-existing codebase. We’ve been improving off of our prior code for years. The particulars we want to focus on are thus:

- Pose
    - This class uses the IMU to approximate the location of the robot on the field relative to the starting position. The math behind this is simple; we use trigonometry to calculate the short-line distance between the robot’s prior location and its current one.
- OpenCV
    - We use OpenCV to recognize particles in autonomous. To do this, we trained the software to differentiate between gold and silver particles. To extend our knowledge of computer vision, we ran tests of OpenCV vs TensorFlow CNN in Python to see if there would be a meaningful runtime difference.
- PID
    - At this point, PID is common among FTC teams. However, as we moved to a new driving base for the first time in three years, we had to retune it, so we rewrote our code to account for the changes in behavior.

## Design Process

Iron Reign uses two design processes in conjunction with each other to create efficient and reliable parts. First, we use the Kaizen design process, also used in industrial corporations such as Toyota. The philosophy behind Kaizen is the idea of continual improvement, that there is always some modification to each system on our robot that will make it more efficient or more reliable. As well, design competitions are a focal point of Iron Reign’s design process. In these design competitions, team members choose their favored designs that all complete some field challenge, and build them individually. Upon completion of each mechanism, the designs are tested against each other, considering weight, maneuverability, reliability, and efficiency.

This year, we have exemplified this process. Since kickoff, we've had two separate design paths, allowing us to explore the most efficient and workable design. Here, we will describe each segment in detail.

First, we explored chassis designs. Over the summer, we created BigWheel, the aforementioned paragon of uniqueness - operating off of just two wheels. Then, we created the MiniChassis to compete against it, letting the best robot win. As of now, this is undecided, but we're entering BigWheel to compete, as we feel that this is our more technically-impressive robot through its ability to rotate into a vertical position.

Then, we compared intake mechanisms. First, we created the Corn-Cob intake - a silicone ice cube tray - and mounted it on a beater bar that would ensure sorting through the height difference between blocks and balls. We found that if we mounted it at about 6.5 cm above the ground, it would only consume the silver particles. After, we felt that this wasn't our best work. So, we created a second intake. As described previously, we attached silicone oven mitts to a beater bar, and added lower fins as a ramp separated 68mm apart so that blocks would fly through, even as balls entered the intake system.

The best thing about Kaizen is that we can mix-and-match these systems for the ultimate robot. At the moment, we're considering removing the second intake from MiniChassis so that we can replace the Corn-Cob. The fact that we can even consider this system matching casually demonstrates the power of the Kaizen system.