1. Part One: Introduction to FIRST Tech Challenge

1.1. Welcome! If you are reading this you are probably about to embark on the most exciting experience you will ever have while in high school. This first part of this guide is meant to explain the basics of FTC including its complicated yet quite common lingo. Most of the information in this part can be found in more detail in Part One of the Official FTC Game Manual. This guide DOES NOT eliminate the need to review that very important and official document. The rest of this guide is designed to go more in-depth on hardware, software, and marketing as it pertains to FTC.

1.2. What is FTC?

1.2.1. FIRST Tech Challenge is a competitive robotics program for students in grades 7-12 all around the world. Teams typically consist of 5-12 people and come in all sorts of shapes and sizes. Your team is your family for the 6-8 month season and most likely longer. Each team has a different vibe to it; some being extremely serious, some being super fun-loving, and many others being a unique blend of both. In time you will come to realize that it is these differences that really make FTC special.

1.3. The Game

1.3.1. The main event of every FTC competition is the robot game. It is played on a 12ft by 12ft field by two ***alliances*** of two teams each. These alliances are randomly selected by the competition software so sometimes the odds may be stacked against you, but triumph is always a possibility. At a competition, you should arrive at the competition floor at least two matches before your scheduled match to get in the ***queueing line***. Each match starts with a 30-second ***autonomous period*** where the robot will follow pre-programmed instructions. Then, when the referees instruct you to, you may pick up your controllers and get ready to start the ***Tele-Operated*** portion of the match. At the end of the match, one alliance wins, and the other loses.

1.3.2. Competition Structure

1.3.2.1. Teams advance to higher levels of competition following a specific ladder. The first step is qualifiers, which can contain anywhere from 12 to 30 teams. These qualify a team for a regional championship. This is commonly a state level competition except in states with larger quantities of teams (such as Texas) These vary greatly from place to place, but typically contain 30-70 teams which all compete for a spot to advance to a Super-Regional tournament. There are four of these in the United States (North, East, South, West) which contain around 72 teams. The final rung is the World Championship, which contains 128 teams from around the world. The robot game part of the competition starts out with a series of randomly assigned round robin matches. The number depends on the competition, with most qualifiers having 5 to 6, most regional tournaments having 6-7, Super-Regional tournaments having 7-9, and the world championship having 9-10 depending on the year.

1.3.3. Team Ranking

1.3.3.1. Teams are ranked based on their performance in their matches. They are first ranked on their ***QP (Qualifying points)*** and then on their ***RP (Ranking points)***. Qualifying Points are awarded based on the outcome of a team's matches. 2 points are awarded for being in the winning alliance of a match, 1 point is awarded if a match results in a draw, and no points are awarded for a lost match. Most often, many teams have the same number of qualifying points, so teams are then ranked by their Ranking Points. Ranking points are given after each match and equal the score of the losing alliance, whether the team was part of it or not.

1.4. Judging

1.4.1. The Formal Interview

1.4.1.1. The first part of every competition day is the Judges Interview. This is a 10-15 minute presentation given by the team to a panel of judges. This is the team's chance to tell the judges anything and everything they need to know, including but not limited to the following:

1.4.1.1.1. Who are you? The judges want to know who you are as a team on a day to day basis. How does your team run? How do you work together? What makes you tick?

1.4.1.1.2. How do you help the community? The judges want to know how you are connecting with the community and what you are doing to spread the messages of FIRST.

1.4.1.1.3. How did you build your robot? What was the PROCESS, not just the end result. The judges want to see that you improved your robot throughout the season because they know that it didn't start out as good as it may be now.

1.4.1.1.4. What makes your software so special? What new things did you try? How did you challenge yourselves? How does the code actually work? Prove that you know exactly what you are doing and that you are doing new things to solve problems.

1.4.1.1.5. What makes you so special? Why are you ANY better than all of the other teams around the world with a successful robot?

1.4.2. The Informal Pit Interview

1.4.2.1. The judges will also come around to each teams pit area to observe and ask more questions. This is a pretty easy process, yet is quite important to the judges. They want to ask more information about certain things and want to see you in action. This is also a time where other judges come and ask questions to help them decide on awards winners. Just follow some simple tips and you will be golden!

1.4.2.1.1. Don’t have every team member in the Pit, it just gets too crowded.

1.4.2.1.2. Keep your Pit area clean. One of the worst things for the judges to see is a messy Pit with trash everywhere. Clean up after yourselves.

1.4.2.1.3. Always have at least 2 or 3 knowledgable people in the Pit that can answer questions if needed.

1.4.2.1.4. Look busy and excited in the Pit. Never sleep, play games, text, etc. in the Pit area.

1.4.3. Other Judging

1.4.3.1. Keep in mind, you are constantly being judged. A judge could be looking at any time, so never act inappropriately or in any way that could reflect bad on your team. They typically walk around and just observe as well as watch matches to see how teams behave. But remember, they still want to see you having fun!

1.5. Spirit

1.5.1. Team spirit is an essential part of every FTC competition. When you walk through the pits at any event you will see tons of people dressed in funny costumes, wearing facepaint, or sporting so many team buttons that you can’t even tell what color their shirt is anymore. The arena area is even more crazy, full of people screaming, chanting, waving flags and signs, and full of pure excitement. Most of this depends on the team, especially in regards to what they wear, do, and chant. Don’t be afraid to act goofy and have spirit, be happy and just have fun.

2. Part Two: Hardware

2.1. Hardware is the actual building of the robot. It involves the design, development, fabrication, and construction involved with creating a complex and competitive robot. Just doing hardware is easy, however doing **GOOD** hardware is not.

2.2. Step One: Design

2.2.1. The key to building any successful mechanical system is planning. You need to figure out **what** needs to be done and **how** you are going to do it.

2.2.2. Define the Problem

2.2.2.1. The first step is to figure out what needs to be done. What tasks does the robot need to perform? How can you score the most points? (Speed, Higher point items, etc.) What things **need** to be done and which are extra? What constraints do you have? Questions like these need to be answered before starting to generate ideas.

2.2.3. Brainstorming

2.2.3.1. Brainstorming is the next step after defining the problem. Here is where you generate ideas on how to solve the problems defined in the first step. Think of ideas that could work yet are still in the constraints defined. It is a fairly open process but there are a few rules:

2.2.3.1.1. There are no bad ideas (Mostly…)

2.2.3.1.1.1. Ridiculous ideas are not ideas and don't count

2.2.3.1.2. Think about each idea, don't immediately shoot down an idea unless it fall under the category described above (2.2.3.1.1.1)

2.2.3.1.3. Be prepared to explain and defend your idea. If you suggest an idea, explain how you came up with it. What was your inspiration? What makes it good?

2.2.4. Evaluate Solutions

2.2.4.1. Now that you have come up with a lot of ideas, you need to evaluate them. Look at all of the ideas generated in brainstorming and start by grouping any mostly similar ideas together (i.e. Two different types of spinners dumping into a similar basket could be grouped together as different variations)

2.2.4.2. Next, think about each idea in a preliminary sense and make sure it fits the basic constraints and can accomplish what you need.

2.2.4.3. Then, for each idea identify the pros and cons. What tasks can it do? What are the limitations? How efficient is it? How complex is it? (Simpler can be better)

2.2.4.4. Then, once you have weeded out ideas that are impractical or that won't work well, you can take the ideas that are left (typically around 3-5) and start prototyping.

2.2.5. Prototyping

2.2.5.1. Prototyping is essential to a robot's success. Prototyping should start with simple materials such as cardboard, tape, or paper, so as not to waste time or materials on an idea that might not work. (We once used a cardboard basket during several scrimmages before creating a real version of 3d printed parts and polycarbonate.)

2.2.5.2. Split up your hardware team and have them each take an idea and prototype and test it to see which concepts work better.

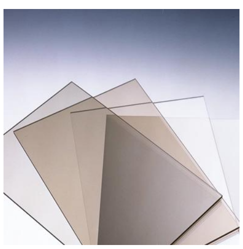
2.2.5.3. Once you have evaluated the pros and cons of each and decided on a winner, you can move on to fabrication to create a better version of it.

2.3. Step Two: Fabrication and Construction

2.3.1. Once you have designs, you can start to create them. The first thing that should be done is CAD (Computer Aided Design). This helps to get plans for the exact way it will be created, and allows you to work out many major issues BEFORE building them. Once you have plans, you can start constructing your designs.

2.3.2. Materials

2.3.2.1. There are tons of different materials that can be used, and they each have a variety of uses.

Material	Description	Uses	Where to buy?
Metal 	Metal is the most basic of building materials. It is strong and can be shaped to whatever is desired. Aluminum is lightweight and easy to work with, steel is stronger but heavier and not as cheap. Comes in many varieties (Block, Sheet, rod, etc.)	Most part of a robot. It is strong, and easily modifiable, making it useful for almost anything, just keep in mind that it does conduct static electricity.	Home Depot, Lowes, McMaster-Carr, Grainger, etc.
Wood 	Wood is from trees, (obviously) and is non conductive. It varies in weight, but isn't known for its lightweight properties. It is also not as strong as some other materials, but allows for things that other materials don't.	Can easily be carved out to inset mechanics (i.e. gears, sprockets) can be used where a wall is wanted that is thicker than metal and can be on its own.	Home Depot, Lowes
Lexan 	Lexan (aka Polycarbonate) is a relatively strong and flexible lightweight plastic. Can easily be formed/bent when hot, easy to cut, easy to work with, doesn't conduct electricity.	Body armor (Shatter-resistant), insulation of electrical components, rapid prototyping.	Home Depot, Lowes, ePlastics, Amazon

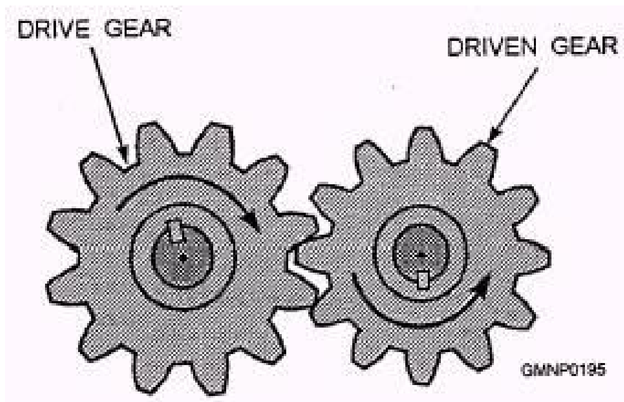
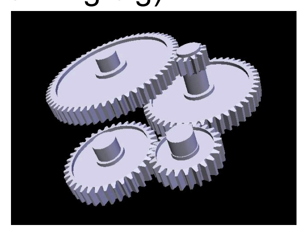
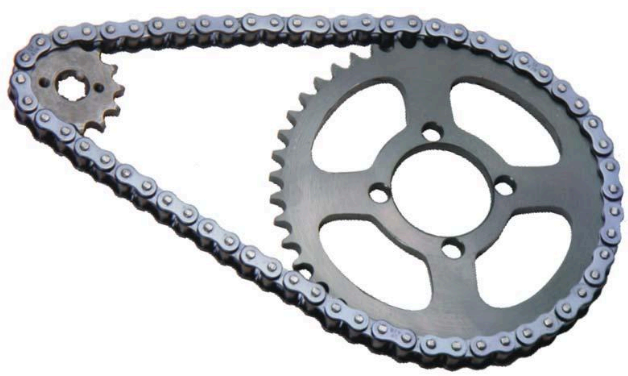
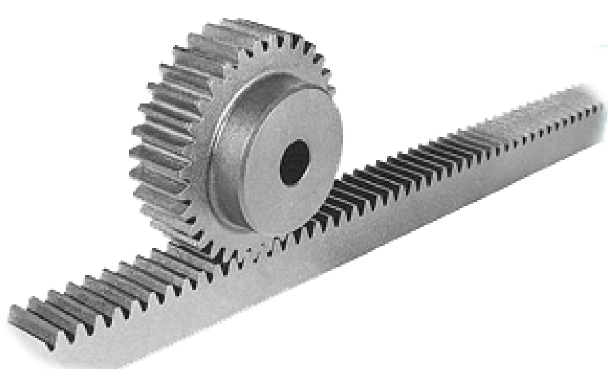
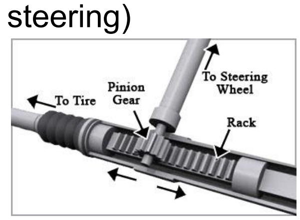
2.3.2.2. There are many more options out there, but make sure to choose your materials wisely and consider pros and cons of each.

2.3.2.3. Forming Lexan

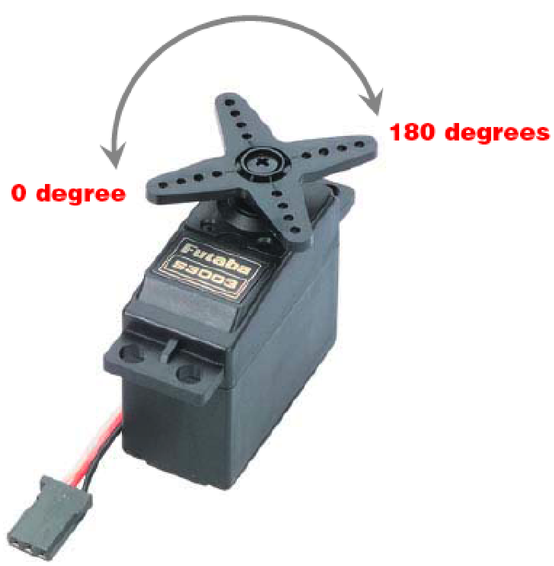
2.3.2.3.1. Lexan easily bends when heated and thus is useful for a variety of needs. To bend it, simple heat along the bend line with a heat gun, heating bar, torch, etc. It typically becomes quite malleable around 350 degrees fahrenheit.

2.3.3. Mechanisms and Power

2.3.3.1. An essential part of hardware, is knowing how to take ideas and create a physical solution to make them work. There are a variety of mechanisms that can be used to accomplish this.

Mechanism	Picture	Type of Motion
Gears		Used to transfer rotational motion, different sizes increase speed (Big driving small) or torque (Small driving big) 
Sprockets		Same as gears but use chain to connect to each other instead of direct contact. Useful for longer distances. (Ex: Garage Door)
Rack and pinion		Linear motion. Pinion gears moves linearly along the rack. (Ex: Car steering) 

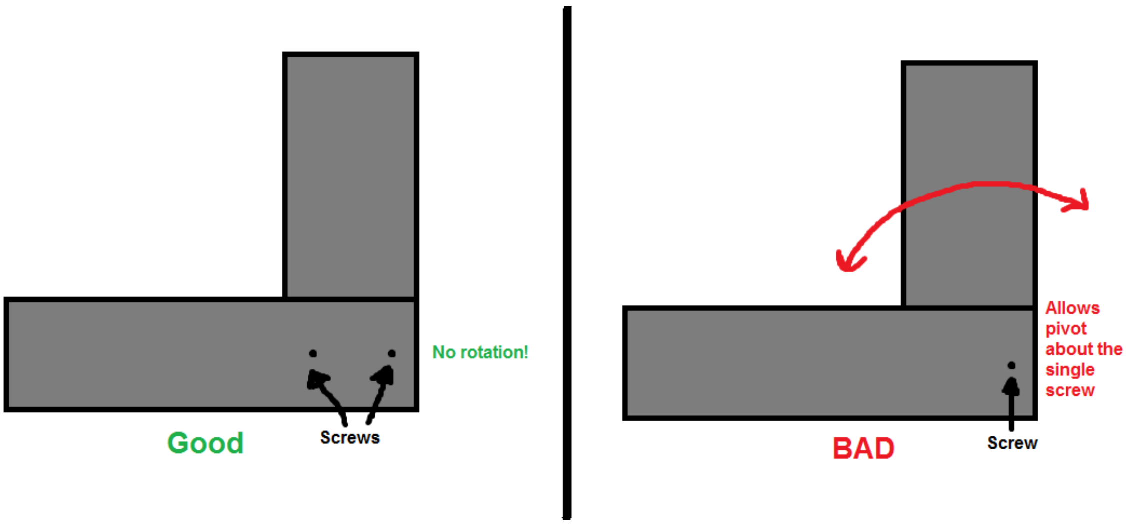
Linear Slide		A linear slide is just a way to facilitate linear motion. (Ex: Drawers, Keyboard trays, etc.)

Motors		Turn on to a certain speed (power) and continue to spin in one direction until power is removed
Servos		Set to move to a certain position. (Most servos typically 180 degrees of movement) Less powerful than a motor however.

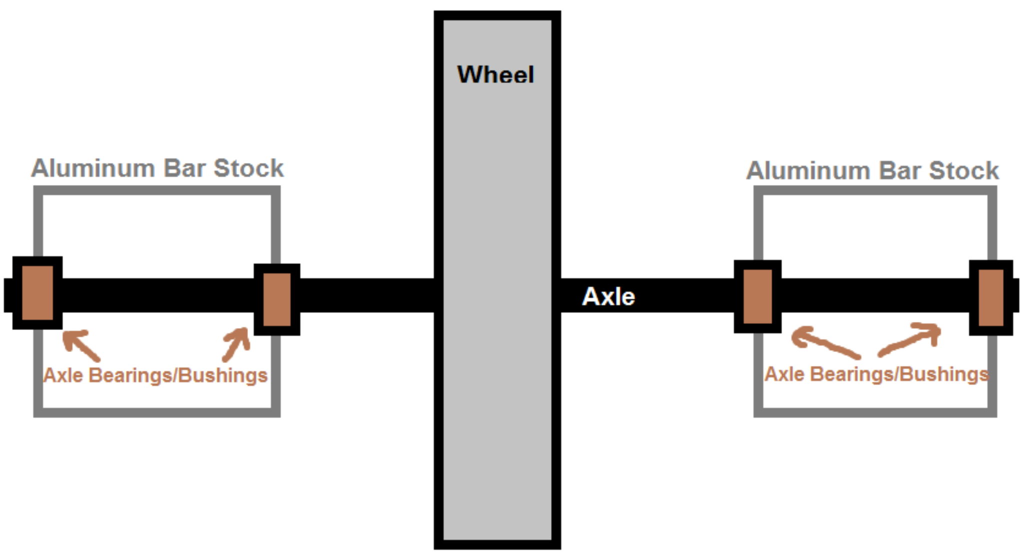
2.3.4. Structural Stability

2.3.4.1. Building a structurally sound mechanism is extremely important and contributes to the ultimate success of the system These guidelines will help to accomplish this.

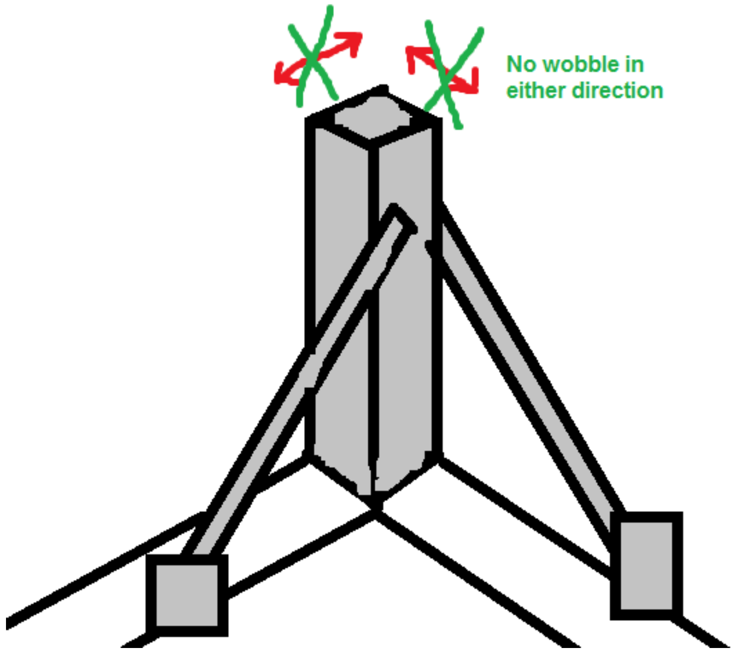
2.3.4.2. When screwing together metal, don't use just one screw. use two per each lateral direction so as to prevent pivoting about a pivot point.



2.3.4.3. All axles need to be supported in at least TWO places. This refers to the stationary points in relation to the axle. (Not anything attached to the axle i.e. a wheel or a sprocket) Ideally these places are on opposite sides of the main load.



2.3.4.4. Wobble on upright segments can easily be addressed by adding angled support beams in the x AND y directions



2.3.4.5. When creating a drivetrain, try to avoid direct drive, that is, don't put the wheel directly onto the motors but instead connect the two via chain, belt, or gears. This will also allow for the ability to adjust the movement speed of the robot. (Achieved via gear ratios in gear/sprocket trains)

2.3.4.6. When creating gear trains, make sure that the axles the gears are on are supported well enough so that they do not lose contact with each other due to separation or the gears pulling apart from each other. This is one reason that sprockets and chain are a good idea as the chain consistently keeps the sprockets in their correct positions.

FOR MORE (+ MORE DETAILED) TIPS:

This guide is meant for new FTC teams as well as returning teams looking to organize a quality season. It is mainly meant for the team's Hardware subteam--but in the ideal team everybody understands everything to a degree so software and marketing members are highly encouraged to read this as well.

We are writing this guide because our own 2020-2021 and 2021-2022 seasons have been fraught with Hardware issues stemming from a rookie hardware team and a loss of talent during the Covid-19 pandemic. It is both to remind ourselves of the lessons which we have learned over these past two years, and to help both our new team members and future competitors to be the best that they can be.

Regardless of who is reading this--Good luck. We hope that you find this guide useful, and use it to make your team and robot the best that it can be.

--QuadX

https://docs.google.com/document/d/1sVwmUhjZqwG8t5wcol6isDd5qjLvz99-7iqxqbYLY6Y/edit?usp=sharing