MOE, Miracles of Engineering
FTC Team 365
2018-19 Design Process

Introduction

Throughout the design of our robot, we have kept one universal theme in mind.

User Friendliness: The measure of how robust, simple, easy to maintain, and easy to use the notebook is.

We wanted our notebook to be easy to write and also easily understood by readers without sacrificing the quality of our notebook entries. Our goal with the notebook is to document all of our experiences, decisions, and reasonings behind those decisions. All in all, it may seem complicated and lengthy to write every experience and decision, but we made it easier to write *and* read by following one universal design process.

The design process not only helps us make smart mechanical decisions, but also serves as a guide for our notebook entries: our thought was that if we follow the design process throughout our decisions, we can easily write about each step that we follow.

This makes things easier to write because all of our decisions can be supported by a universal design process: everyone has a reason behind a decision, but that reasoning may be hard to explain. With an overall understanding of the design process, it is easier to understand why we made the decisions that we did. Also, each step of the design process has a description of the information that it should contain, so crucial procedures do not get glanced over.

This also makes things easier to read because our design process is implemented with a color-coded system that everyone can follow: a rainbow. This rainbow shows our progress through the design process—the further down the rainbow we are, the closer we are to a finished project. Also, each step of the design process is labeled with each entry that we do.

Design Process Diagram

Title:	Title Should Be One/Two Word Summary of Problem ○ (e.g. "Drivetrain", "Chassis", "Harvester" "Intake")
Define Problem:	• Specify the problem • Document specifics (the number of points the problem is worth, the level of importance/priority)
Generate Concepts:	• Brainstorm solutions to the problem • Narrow down to a singular solution ○ Use Design Matrix ○ Analyze Pros and Cons
Develop a Solution:	• Create rough sketch of solution • Create CAD of solution *If Design does not show promise, go back to a different concept*
Construct and Test Prototype:	• Make a prototype based off of CAD ○ Can be rough or specific • Analyze outcome of prototype ○ "Prototype works with 80% accuracy" ○ "Design may need tweaking – Prototype does not work very well"

	○ "The plastic prototype doesn't work but the final mechanism will be made of aluminum and that should work" ○ "A tiny design change helped the prototype – Add to CAD" *If Prototype does not show promise, go back and improve the design*
Fabricate Solution:	• Fabricate a finalized solution based off of the CAD • Put item on robot
Evaluate:	• Evaluate the effectiveness of solution • Analyze flaws and where tweaks can be made
Tweak:	• Improvements and changes to final design

The Design Process

The design process always starts with one thing: defining a problem. These problems are just any situation that needs to be overcome, such as having a screw that is too big to fit in a whole. These are overlying problems that need to be solved with a mechanism/system. Specifically, in FTC, our problems are trying to complete the point-scoring objectives.

Once a problem has been identified, a solution must be found. If someone just attempts to build a mechanism to solve the problems with any planning or preliminary procedures, it will most likely not be the best design or maybe not even work. That is why it is very important to plan!

The first step of planning is generating concepts, also known as brainstorming. During this stage, no ideas are ignored, for something that may seem like a bad idea may actual be the best idea! After listing as many ideas that we can think of, it is important to extensively compare the pros and costs of each idea. This can be done using a design matrix that prioritizes/weighs the pros and cons and assign a rating for each design. After this whole process, a final decision of a solution is made (sometimes multiple solutions depending on how easy it is to test one).

The next step is so plan out the design of the solution. This step is crucial to see whether our concepts our actually designable. Design can be done by hand, but preferably in a computer software to get a better idea of the design as a whole. If the design looks promising, then we can move on to prototyping.

Prototyping is a very important state in the design process. A robust solution may take a long time to fabricate, but it would be upsetting to see it not work at the end. With prototyping, we can make a less robust design to test the concept before actually creating the solution. Prototypes can be as easy as something made of cardboard, but it can also be made out of more reliable material such as polycarbonate. The more robust the prototype, the more accurately it would represent the real thing (something that may work with cardboard may not work with aluminum).

If the prototype works, then we can finally start fabricating the solution. We follow the designs that were previously drawn as well as make (and document) any design changes that are needed, but we did not foresee. Then, the mechanism can be put on our robot for testing and evaluation. More tweaks can be made after we see the performance on the robot.

This whole process is iterative: it is a procedure where we can get a desired result (a solution) through repeated cycles. Following this design process is not always a linear, start-to-finish procedure; we can take step back from a path if something does not end up working with the knowledge that we gained from going through that path. If a prototype does not work, then we can refine the design OR go back to a previously generated concept. Like all iterative processes, a desired result would converge with more iterations.

Integration into the Notebook

This procedure can easily be implemented into our notebook. We sectioned out each step of the design process and used the same color-coding system as the diagram shown above. Through this, we can always follow what step of the design process we're on and what we should be doing.

Also, since this is an iterative design process, it should be able to flow between meetings throughout the whole season. The design processes should start at the beginning of the season and end at the end of the season because a design is never truly done because there is always room for improvement!

This is able to flow between meetings by having a title for each process. If someone wanted to see the journey of our team marker mechanism throughout the whole season, they can flip through the notebook entries and read anything titled "Team Marker Mechanism" and it will pick up where it left off last time it was worked on. Hypothetically, we could print out all the entries that say "Team

Marker Mechanism" and glue the title of each thing to the bottom of the previous meeting.

Also, we have action blocks that where we assign tasks to students before entering the lab, so readers can read the action blocks to see what we planned to get done or planned to work on during the meeting. Action blocks do not cover everything that is done because a team member that finishes their tasks can do more than what was planned.