The Optical Engineering Design Process

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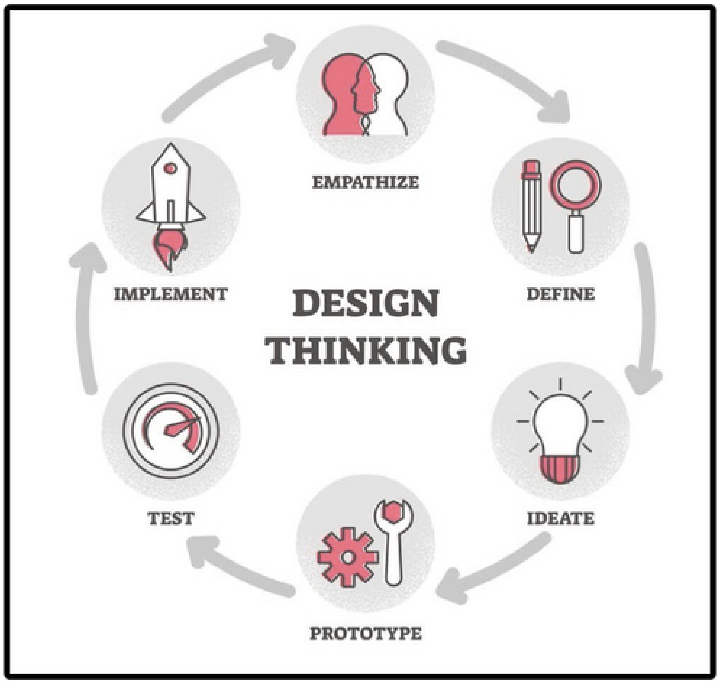
Why Choose Optical Engineering?

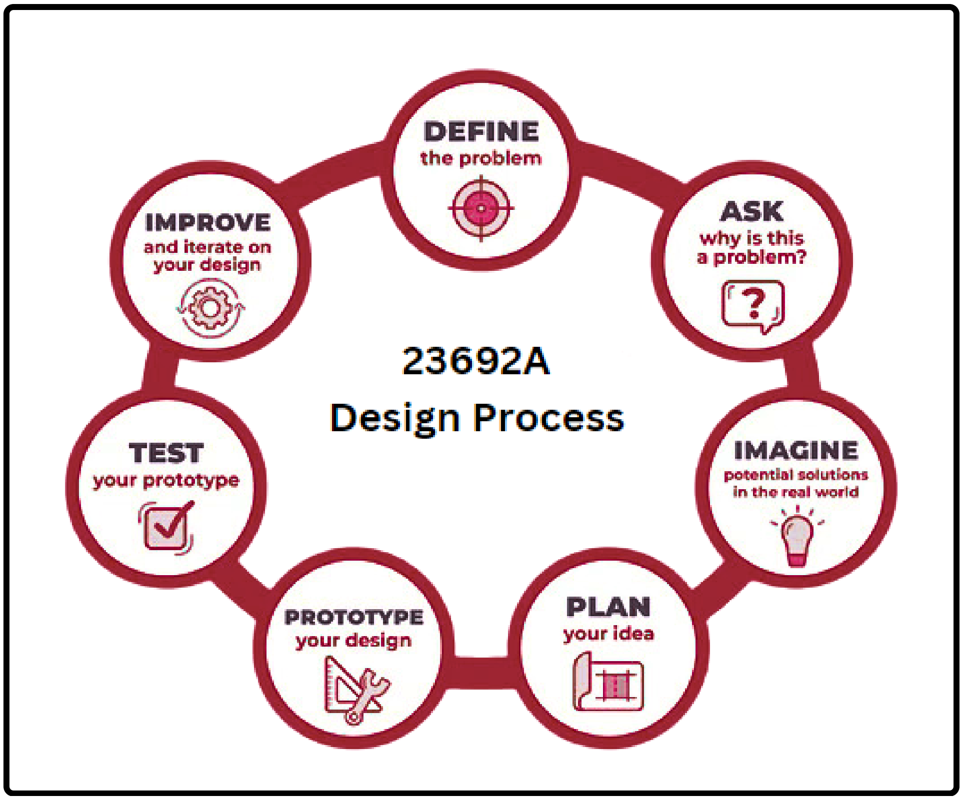
Optical engineers are increasing in demand, helping improve our current technologies, while developing new ones. Optics play an important role in our society, from lenses invented almost 3,000 ago to headlights that allow us to see in the dark. Modern inventions also include cameras, laboratory microscopes, and weather forecasts based off data collected from devices created by optical engineers. This career focuses on how to use light in effective ways. It impacts industries like defense, telecommunications, aerospace, energy, healthcare, and entertainment. It was not just the prominent relevance of optical engineering that intrigued our team, but how the career's values align with our team's work ethic and performance: communication, cooperation, and determination. We reached out to Aboubakar Traore, an optical engineer at NASA, for insight on how optical engineers undertake their design process.

Aboubakar Traore looking over Doppler Aerosol Wind Lidar (DAWN) in 2019.

Design Process

Design process provides engineers a guide through their ambitions to achieve their goal. The image on the right shows an optical engineer's design thinking path. Our team's engineering design process is slightly different, but both depict similar ideas and course. As a new challenge is assigned, we continuously use the same design process.



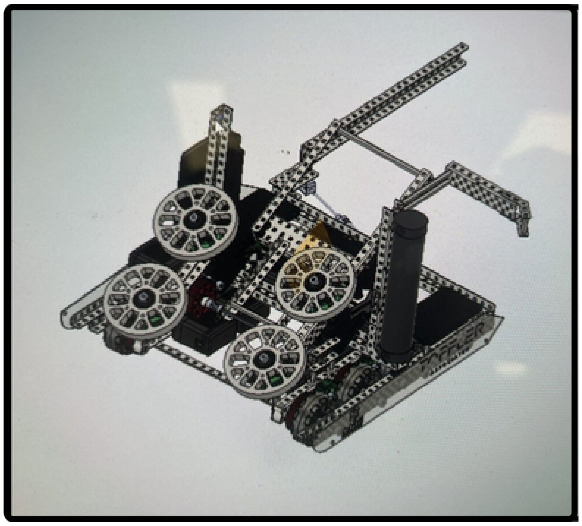


(above): Optical engineers' Design Process

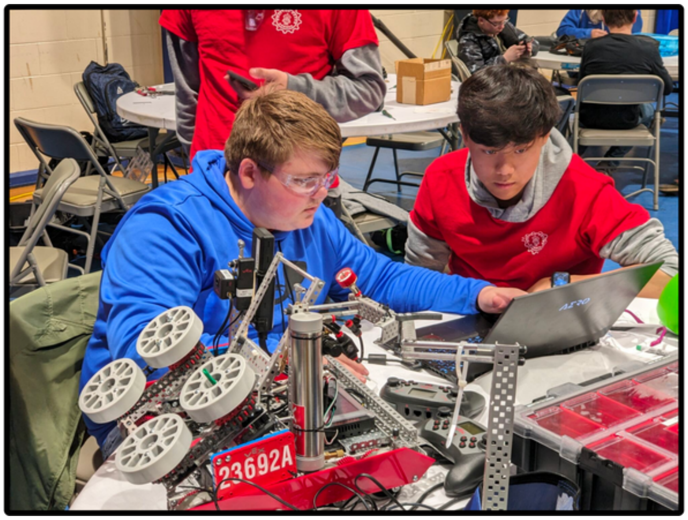
(left): 23692A's Design Process

Step I: Empathize

Optical engineers must have a firm understanding of what they aim to complete. They recognize troubles that people, environment, or devices face and attempt to offer solutions. Traore stated, “Research and understanding the concept is the absolute most important part in the process.” He listed ways to research, such as “looking over lab work and past research or asking colleagues and head leaders. We also perform secondary research by exploring existing solutions.” In our case, we review work from past years’ competitions, games, and robots, which give us basic ideas. Also, YouTube provides lots of easily accessible information. At our first competition, we recognized teams using flywheels instead of catapults. As a result, we altered our design during the competition, improving our performance.



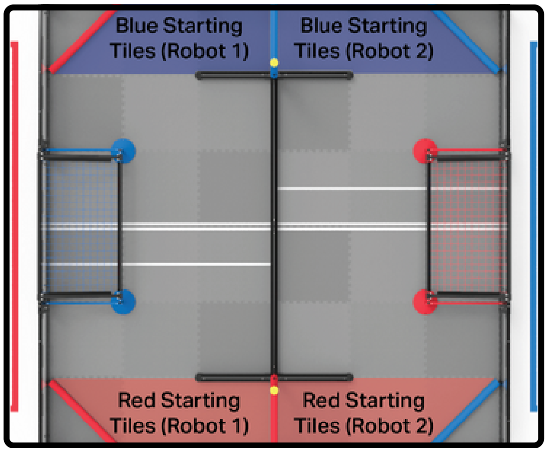
Our initial design with a catapult.



Tanner (left), our lead designer, and Will (right), our lead builder, designing a flywheel mechanism.

Step 2: Define

Based off completed research, the next step is defining the problem. Optical engineers work to solve many issues. Traore listed a few: “Environmental, medical, and problems humans face in their everday lives.” Engineers want to ensure what they’re creating will function well and make life easier. Our team has to solve the problem of designing and building a robot to compete and score points in the annual game. Our problem is defined from the game manual rather than needfinding.



Specific game rules in the Over Under VEX Robotics Competition.


VEX ROBOTICS COMPETITION OVER UNDER

2023 - 2024

Game Manual

Version 2.2

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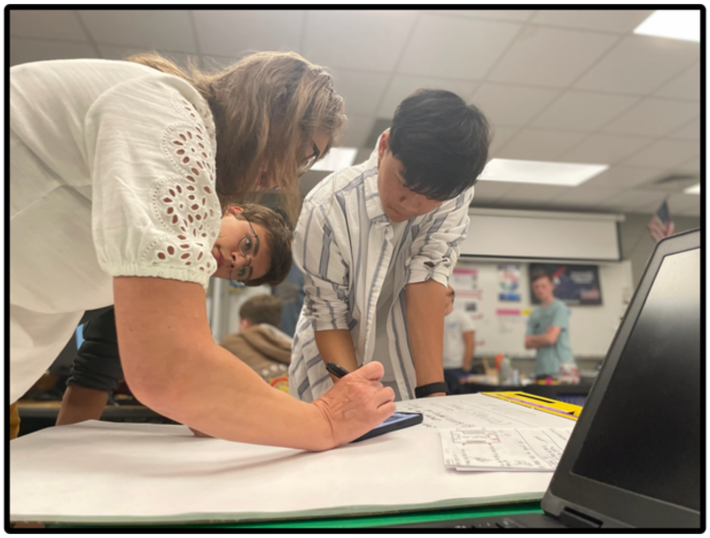
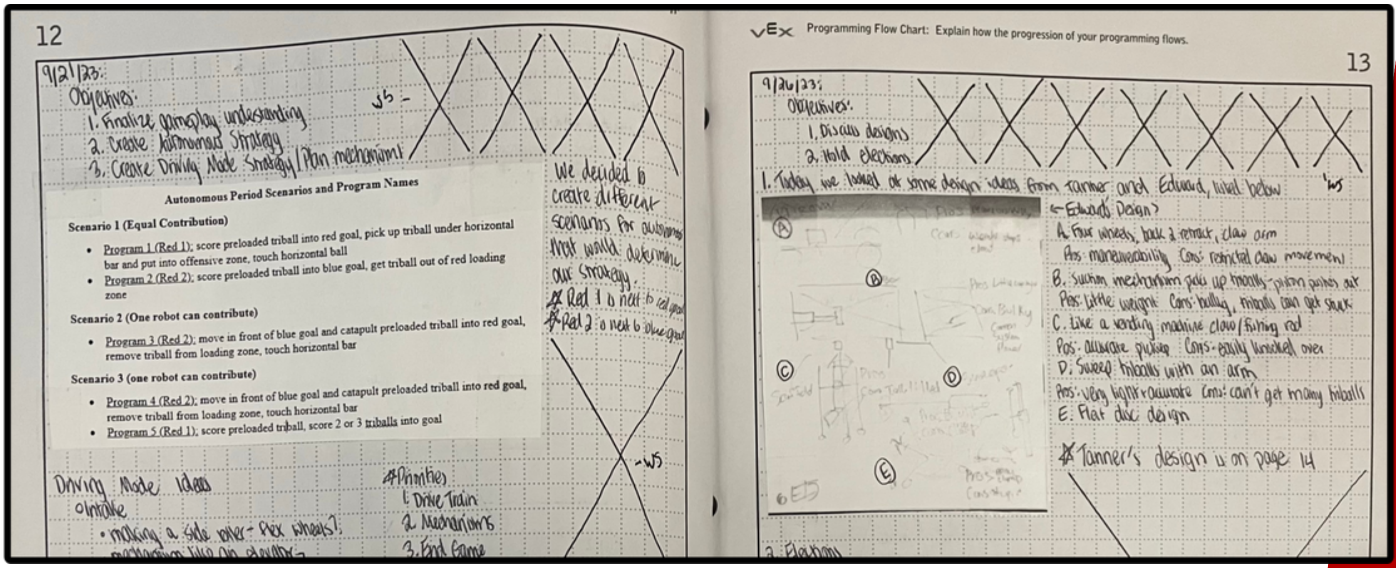
Step 3: Ideate

The task of developing ideas is cooperatively split. Optical and mechanical engineers work in tandem to create multiple solutions. Then, select the best idea. Similarly, our team is split with designers, builders, and programmers working together to develop better, more effective and efficient concepts. We choose the one that we believe would work best with our robot.

(right): Will, our lead builder, and Paul, our lead programmer, present concepts to our coach.

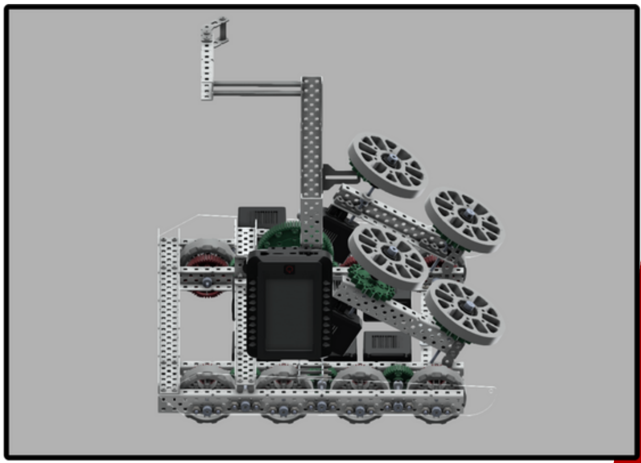
(below): Two pages from our notebook showing concept generation and autonomous period scenarios.



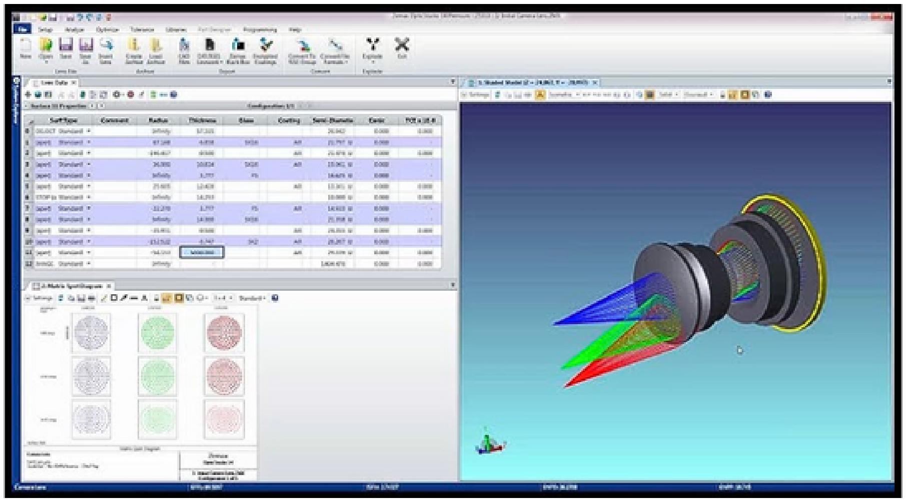


Step 4: Prototype

Creating a prototype provides engineers a 3D visual representation of their design. Traore said, “It’s basically a preview of what’s going to be made.” Optical engineers model with CAD and for modeling lenses they use ZEMAX OpticStudio. After creating the design, they present it in a meeting with colleagues and head leaders. Once the instrument is approved, it’s built as an Engineering Test Unit (ETU). Our team also uses CAD, specifically Fusion 360, to develop a model of the robot. It’s easily accessible to all team members. We’ve gone through three iterations, improving the prototype after each competition (test).



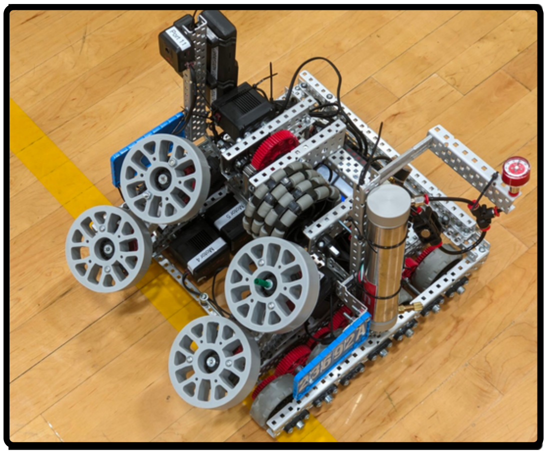
Our robot’s rendered design in Fusion 360.



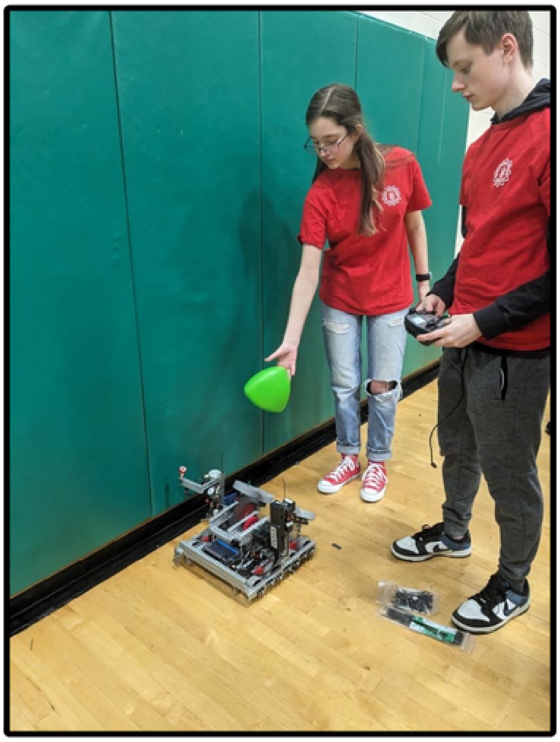
A lens being modeled in ZEMAX OpticStudio.

Step 5: Test

After creating a prototype, it's time to test. Optical engineers must test everything they've designed to ensure proof of accuracy, it meets requirements, and can be produced. We test our robot on our practice field, simulating competition conditions. If a certain mechanism fails to work as expected, we go back to step one and attempt to improve it. The real test is our performance in competitions.



Our robot after the first competition, with an initial flywheel.



Our drive team testing the flywheel.

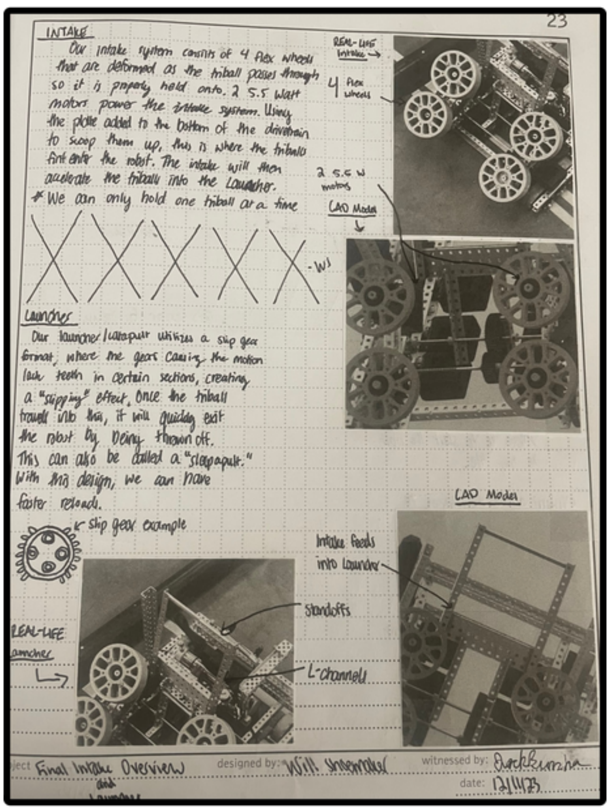
***Mechanical Enhancements:**

Replace the current intake with a U-shaped hippo intake.
Transition the flywheel to flex wheels.
Construct plows that extend
Develop a guidance system for the flywheel.
Ensure proper attachment of the flywheel.

A list of our decided changes for our robot after our second competition.

Step 6: Implement

After the instrument is created, optical engineers hold another conference showcasing the new device. Once they get final approval, the device is ready to be used. Our team describes our design to judges at competitions. In addition, our engineering notebook explains in great detail our whole process and how our robot works.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INTAKE

Our intake system consists of 4 flex wheels that are deformed as the triball passes through so it is properly held onto. 2 5.5 Watt motors power the intake system. Using the plate added to the bottom of the drivetrain to scoop them up, this is where the triballs first enter the robot. The intake will then accelerate the triballs into the Launcher.
* We can only hold one triball at a time

REAL-LIFE Intake →

4 Flex wheels

2 5.5 W motors

CAD Model

Launcher

Our launcher/catapult utilizes a slip gear format, where the gears causing the motion lack teeth in certain sections, creating a "slipping" effect. Once the triball travels into this, it will quickly exit the robot by being thrown off. This can also be called a "slapapult." With this design, we can have faster reloads.

← Slip gear example

CAD Model

Intake feeds into launcher

Standoffs

L-channels

REAL-LIFE Launcher

project: Final Intake Overview and Launcher — designed by: Will Shoemaker — witnessed by: [illegible] — date: 12/11/23

(above): A page of our notebook explaining the mechanisms of our robot.

(top right): Our team explaining our design to the judge at a competition.

(bottom right): An optical engineer presenting a design during a meeting.

Career Preparation

The skills our team learned through VEX Robotics have many similarities to optical engineering. One of the most important skills we've learned that ties with optical engineering is teamwork. Just as optical engineers work together and alongside other engineers, we rely on each other and support one another no matter the outcome. For 23692A, if one faces a challenge, we all persevere through it together.

Along with teamwork, communication plays a huge role in life. No matter where our separate paths lead, knowing how to communicate ideas with others is vital to advancing in today's world. Like optical engineers, our team shares improvement ideas and how to successfully undertake challenges in the annual game. We converse with our allies in every game to devise a winning strategy that maximizes the strengths of both robots and propose

propose our design to judges through an interview and our notebook.

The quote that sticks with VRC students, daily: "Think like an engineer." We research, develop ideas, create prototypes, and document our work. The values we're learning through VEX Robotics tie together in ways that will last a lifetime and ensure future success.

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