Applied Dynamics Initiative
d.b.a. ENIGMA #16265
4301 Hillspire Ave. NW
Albuquerque, NM 87120
(505) 219-1023

FTC TEAM 16265 ENIGMA
2020-2021 ENGINEERING PORTFOLIO

TEAM SUMMARY

Enigma is a community-driven, practical learning experience led by volunteer coaches, mentors and parents for students interested in STEM and robotics in general. Our team is made up of public schooled and homeschooled students from the Albuquerque and Rio Rancho areas of New Mexico. We currently have 6 students. One of our students has experience with FLL Jr., two have had experience with FLL, eight have had experience in FTC, and three in FRC. One of our team members is new to the program. We also currently have 2 coaches and 1 mentor. Our team strives to be a family and to steward the resources entrusted to us to help grow students in their interests and abilities in STEM fields, their problem-solving and group-work skills, and their business and presentation skills. We are eager to make a difference and to grow FIRST in New Mexico as much as possible! We accomplish these goals through focus on **Individual & Team Building**, **Robotics Engineering**, and **Community Engagement**.

MISSION STATEMENT

Promote Community	Lead	Learn	Have Fun	Build Robots	Help Others	Teamwork

It is our desire to help students thrive in a world of technology and business, and ultimately create mentors that will carry on the torch to the next generation of students. -*ENIGMA 16265*

2019-2020 ROOKIE SEASON SUMMARY

WHAT DID WE ACCOMPLISH?

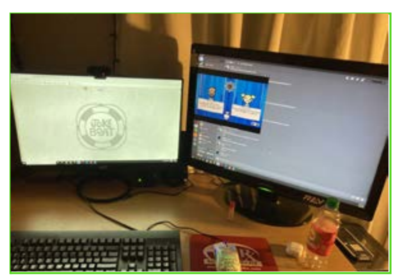
1. **Winning Alliance Captain of 2020 NM State**
2. **Winning Alliance of AZ State Sugaro Division**
3. **Invited to Maryland Tech Invitational at John Hopkins University**
4. **1st place Inspire at first qualifier**
5. **15 total awards**
6. **Fundraised over $12,000**
7. **Over 489 hours of outreach**
8. **Over 1,000 instagram followers**

HOW WE ACHIEVE OUR GOALS

We set very high goals and standards for our team. We believe that if we form a strong foundation, we will grow exponentially in all areas in seasons to come. A huge part of this is defining how we will complete our goals. With the following three focuses, we believe we can build a very strong, competitive, and impactful team.

	MISSION	ACTIONS
INDIVIDUAL & TEAM BUILDING	To form a strong, sustainable team and to grow as individuals going into a world of technology and business	• Team bonding activities • Form an efficient and inclusive team structure • Coaches mentor student leads, student leads mentor other positions • Form a business plan with goals & sustainability plan
COMMUNITY ENGAGEMENT	To spread the impact, mission, and life changing effects of FIRST throughout New Mexico and beyond.	• Host and attend local STEM events • Collaborate with local teams, engineers, schools, and lawmakers • Seek out opportunities to start new teams • Volunteer in the Community
ROBOTICS ENGINEERING	To build a competitive robot and to learn about real world engineering and problem solving.	• Follow an effective Design Process • Utilize math and science • Utilize CAD and mechanical sketches • Consult real-life engineers • Always be willing to learn new things

INDIVIDUAL & TEAM BUILDING | TEAM BONDING



Playing pool together	**Playing online among us together**	**Playing online jack-box games together**

INDIVIDUAL & TEAM BUILDING | MEET THE TEAM

Each season, our members choose what **leadership positions** and **teams** they are interested in. We then all work together to accomplish our goals!

NAME: Ema	AGE: 15	YEARS OF FIRST EXP: 3
ROLES		
Build Team, Fundraising/Outreach Team		

NAME: Gray	AGE: 15	YEARS OF FIRST EXP: 1
ROLES		
Driver One, Build Team Lead, Programming Team, Fundraising/Outreach Team		

NAME: Felix	AGE: 15	YEARS OF FIRST EXP: 1
ROLES		
Driver Two, Build Team		

NAME: Isabel	AGE: 16	YEARS OF FIRST EXP: 4
ROLES		
Team Captain, Code/Electrical Lead, Managerial Lead, Build Team, Fundraising/Outreach Team		

NAME: Tazz	AGE: 16	YEARS OF FIRST EXP: 1
ROLES		
Fundraising/Outreach Team, Marketing Lead, Building Team, Managerial Team		

NAME: Madelene	AGE: 18	YEARS OF FIRST EXP: 4
ROLES		
Build Team, Fundraising/Outreach Team		

INDIVIDUAL & TEAM BUILDING | BUSINESS & SUSTAINABILITY PLAN HIGHLIGHTS

SWOT ANALYSIS

STRENGTHS	WEAKNESSES
● Community-based (frequent meetings) ● Intense student commitment ● Business Plan ● Team works well together ● Very organized ● Workshop with many tools ● Not opposed to change	● Only one year experience as a team ● Lack of mentors ● Lack of funding ● Lack of engineering connections ● Lack of experience with advanced building techniques such as 3D printing and Milling
OPPORTUNITIES	**THREATS**
● Skill & Individual growth ● Grow FIRST in NM ● Collaborate more with other teams ● Secure more sponsors ● Volunteer more in the community ● Connect with the engineering community ● Win State Competition & even Worlds	● Loss of workspace ● Loss of students ● Loss of mentors ● Complete loss of funding ● Experienced students aging out ● Injury

WEAKNESS & THREAT IMPROVEMENTS: 2 EXAMPLES

Lack of experience with advanced building techniques such as 3D printing and Milling:
Mechanical Team, Managerial Team
In order to increase our experience with advanced building techniques such as 3D printing and Milling, we have conducted research on 3D printing and Milling, and have ordered a Mill and new 3D printer. This season, we will utilize the off-season research we conducted and possibly reach out to more experienced people/teams in order to integrate the use of these machines into our robot for a cleaner result.

Experienced Students Aging Out: Managerial Team
Although we can not directly eliminate this threat, we can spread out leadership opportunities and train less experienced members throughout the off-season and league season, in order to ensure that when experienced students age out, the newer students can take over with ease. We will also thoroughly document our experiences and lessons learned throughout the seasons so they can be reviewed each season.

GOALS TIMELINE

2020-21 SEASON / 2021-22 OFF SEASON

- FORM AT LEAST 3 REALLY MEANINGFUL CONNECTIONS WITH THE LOCAL ENGINEERING COMMUNITY
- ADD TO THE WEBSITE AND YOUTUBE CHANNEL

2020-21 SEASON

- FUNDRAISE OVER $8,000
- HIGHEST SCORING TEAM AT A TOURNAMENT
- QUALIFY FOR NM STATE
- PLACE IN OR WIN INSPIRE

2021-22 OFF SEASON

- FORM & MENTOR 2 MORE FTC TEAMS IN NM
- BUILD AN OUTREACH AND PROGRAMMING ROBOT
- HOST OUR OWN ROBOTICS SUMMER CAMP
- INCREASE OUR FUNDING BY 25%

BEYOND

- STEADILY INCREASE FIRST GROWTH IN NM BY OVER 15%
- GROW OUR NON PROFIT INTO A RESOURCE FOR FIRST TEAMS IN NM
- INTRODUCE UNDERPRIVILEGED NM STUDENTS TO FIRST
- SEE FIRST PROGRAMS IN EVERY NM SCHOOL
- SEE 2+ NM TEAMS REPRESENTED AT WORLDS

GOAL ACTIONS: 3 EXAMPLES

THREE MEANINGFUL ENGINEERING CONNECTIONS	OUTREACH & FUNDRAISING TEAM	• Research local engineering companies and events for possible opportunities • Brainstorm what a meaningful interaction/relationship would look like
ADD TO THE WEBSITE AND YOUTUBE CHANNEL	TEAM LOOK/MEDIA TEAM	• Brainstorm ideas for possible content to add to website and youtube channel ○ Team blog, share team documents, tutorials, robot reveals, bloopers • Act on ideas and assign tasks -writing, taking pictures, filming, editing
FUNDRAISE OVER $8,000	OUTREACH & FUNDRAISING TEAM	• Research successful fundraising strategies from other teams • Form a comprehensive plan and assign tasks to students • Follow through throughout the off-season and season • Seek for new connections and fundraising ideas

COMMUNITY ENGAGEMENT | OUTREACH

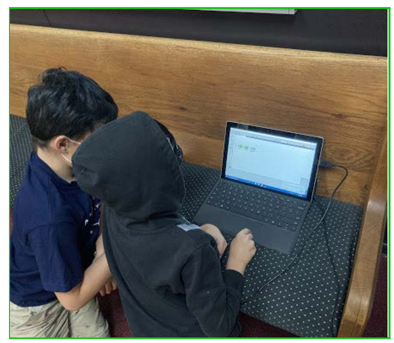
36 Team Hours	**86 Individual Hours**	**13 FLL Classes**	**22 Kids Reached**	**1 Team Mentored**

Since we are a small FIRST state, Enigma strives to grow the FIRST community in New Mexico. We accomplish this by reaching out to our community, and hosting and participating in outreach events to spread awareness of STEM and FIRST in our community. <u>ENIGMA taught the FLL classes through other organizations, and did not set the COVID-19 safety measures. All team members wore masks at all times.</u>

13 FLL CLASSES

We taught two seven-week FLL classes. Each class was split up into two teams of five and were given 1-2 FLL missions to complete. We used the field and challenges from the 2018-2019 FLL challenge, Mission Moon. We taught the kids age appropriate **engineering concepts**, **FLL core values**, and **blocks programming**. They brainstormed, built, and programmed their robots from scratch. At the end of the classes, each team ran their robots and completed their missions.





VIRTUALLY MENTORING MOSCOW MECHANICS

This season we were also able to virtually mentor a rookie FTC team from Idaho that our former member, George, started himself after moving. We helped them with **registration** and guided them in **fundraising**, **recruiting**, **mechanical design**, and **programming**.

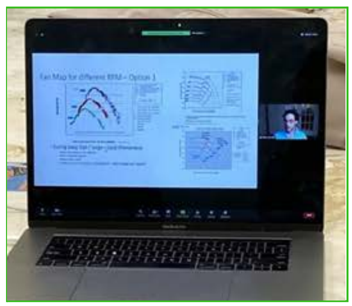

COMMUNITY ENGAGEMENT | ENGINEERING CONNECTIONS

Mechanical Engineer	IT Professional	Robotics Engineer

Forming connections with the engineering community is super important to bring more awareness to FIRST and to better our team and design process!

MEETING WITH MECHANICAL ENGINEER, DANA

We met with mechanical engineer Dana, who works on the Next Generation Very Large Array Antennas, through Zoom! He explained how he led his team utilizing their **design process**. We explained our challenge and **our ideas for the robot**. We asked many questions and he helped us with our design process and the physics of shooting a ring. **We learned** that an engineer's design process is very similar to ours, we should list the requirements of each mechanism, recording performance data is crucial, and rings should have spin when shot so there is no wobble.



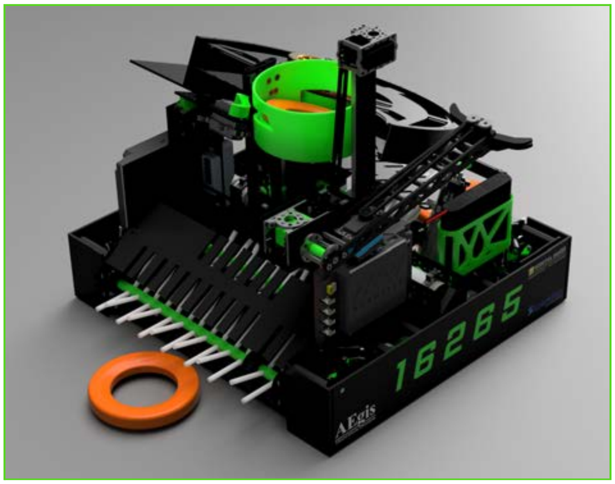
MEETING WITH IT PROFESSIONAL, FRANK

We also had a meeting with IT Professional Frank. We showed him our shop and **demonstrated all of our prototypes**. Once he learned more about our program, he **taught us how to use the Prusa I3 MK3S 3D** printer that he donated to us! He taught us about the software and hardware that it uses. We were grateful for his assistance and he was impressed with our work.

MEETING WITH ROBOTICS ENGINEER, KYLE

Recently, we had the honor of meeting Robotics Engineer, Kyle. He is currently an online student at Georgia Tech and works on drones and autonomous vehicles. He talked to us about the importance of **rigidity** and **multiple points of contact**. He said, "freedom of movement is the enemy of robotics." Kyle also talked to us about his work and told us that we were at a **very advanced level**, working on projects that he was doing in college and even at work. He expressed interest in mentoring us virtually next season!

ROBOTICS ENGINEERING | MEET OUR ROBOT



HUUBRESHTER

Meet our robot, huubreshter! It took many months of brainstorming, prototyping, CAD, fabrication, and finally assembly to create him. He features double sweeper-intakes, a two bar linkage connected to a hopper, a 180° shooter with an adjustable shooting angle, a wobble goal arm, and much more. This was our first year utilizing CAD, a CNC machine, a laser cutter, and 3D printing to this level!

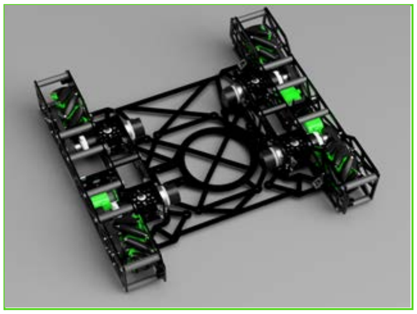
ORIGINAL SCORING ACHIEVEMENT GOALS

AUTONOMOUS	DRIVER CONTROLLED	END GAME	TOTAL
Solo Points: **113**	Solo Points: **54+**	Solo Points: **135+**	**302**
Program One ● All three Power Shots ● Rings (if available) into High Tower Goal ● Deliver Wobble Goal into Target Zone ● Navigatate Program Two ● Navigate	● Shoot at least 9 rings into the High Tower Goal	● Shoot all three Power Shots ● Put 5 rings on each Wobble Goal ● Deliver both Wobble Goals into Drop Zone	

CURRENT SCORING ACHIEVEMENTS

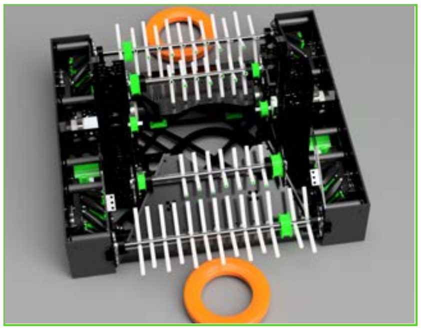
AUTONOMOUS	DRIVER CONTROLLED	END GAME	TOTAL
Solo Points: **80-116**	Solo Points: **96-168+**	Solo Points: **85+**	**261-369**
Program One ● Knock down all three power shots ● Deliver both wobble goals into target zone ● Shoot 0-3 three rings into high goal ● Navigatate	● Shoot a16-28 rings into the high goal	● Shoot all three power shots ● Deliver both wobble goals into drop zone	

SUB-SYSTEM DESCRIPTIONS



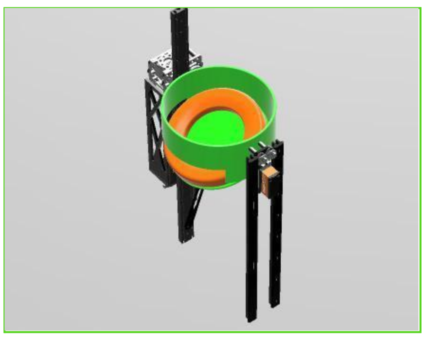
CHASSIS

This season's chassis features ball bearing mecanum wheels, which allow **multi-directional movement**. The robot is driven by four 435- rpm motors, which work out to a speed of approximately **7 feet per second**. The mecanum wheels are run in a dead axle configuration, utilizing ball bearings and 1:1 timing belts and pulleys.



INTAKES

Because rings randomly end up all around the field, we decided to have **dual intakes** for max efficiency. Our sweeper intakes feature **double rows**, driven by two 1780 RPM motors, belts, and pulleys. The grippy surgical tubing has a lifting effect on the rings which **reduces friction** between the rings and floor/ramps!

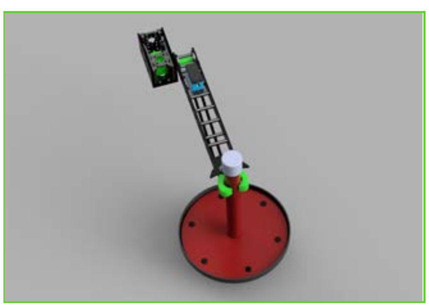


HOPPER & LINKAGE

The intakes drop the rings right into the hopper located in the center of the robot. The hopper then moves up to the shooter via a two **2 bar linkage**, supported by v-guides, and driven by a single servo. The hopper also features a bottom plate that rotates to match the angle of the shooter so rings can slide in with ease.

SHOOTER

The 180° shooter wraparound design optimizes momentum as rings spin around the 4" compliance wheel which is driven by two 6,000 RPM motors belted together (**doubled torque**). The shooter also has a weight on the axle for **inertia** and an **adjustable take-off angle plate**.



WOBBLE GOAL ARM

The wobble goal arm is rotated up and down by a servo in a custom servo block. The clamping servo is mounted close to the point of rotation and belted to the 3D printed claw to **reduce strain** on the rotation servo. The claw is covered in rubber bands to **increase grip**.

ROBOTICS ENGINEERING | DESIGN STRATEGY & PROCESS

DESIGN STRATEGY

Simple	Rigid	Linear	Measured in Seconds	No Unnecessary Motion	Occam's Razor

When designing, we are always thinking about the fastest possible way to get the game piece from its 'default location' to its 'scored location'. There is **no unnecessary motion**, and the mechanisms that complete each task are **fine tuned**, **simple**, **rigid**, and **linear**. Each mechanism, whether isolated or parts of a whole, should be linear and quick, similar to **Occam's Razor**. Each mechanism's ability to complete its task is measured in seconds. Mechanisms are improved as much as possible to achieve the fastest system of moving parts.

From a competition standpoint, we are only competing against ourselves and the clock. In each round, we have 2 minutes and 30 seconds to complete the greatest quantity of tasks possible. It is always our goal that our robot completes **all autonomous tasks**, and, in tele-op, do **each task as efficiently as possible**.

DESIGN PROCESS

ANALYZE PROBLEM

1. Decompose challenge tasks
2. Conduct point analysis
3. Identify goals
4. Specify Solution Requirements
    a. Size
    b. Weight
    c. Speed
    d. Other

BRAINSTORM SOLUTIONS

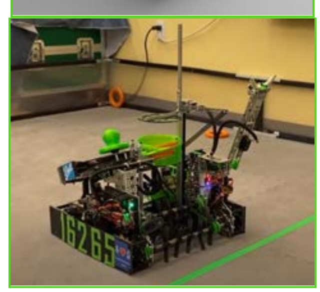
1. Research
2. List ALL designs
3. Sketch designs
4. Form pro-con lists
5. Further analyze and narrow designs down

PROTOTYPE

1. Rough Cardboard prototypes
2. More robust prototypes
3. Collect Data
4. Narrow down to one design element per system

IMPLEMENT & EVALUATE

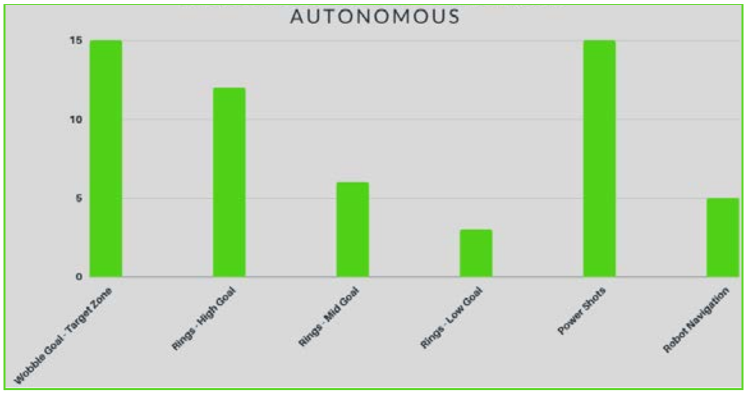
1. CAD design elements
2. Assemble design elements
3. Test, Collecting Data
4. Compare performance to initial goals and requirements
5. Analyze overall simplicity, robustness, and speed
6. Identify deficiencies in design
7. Prioritize necessary adjustments

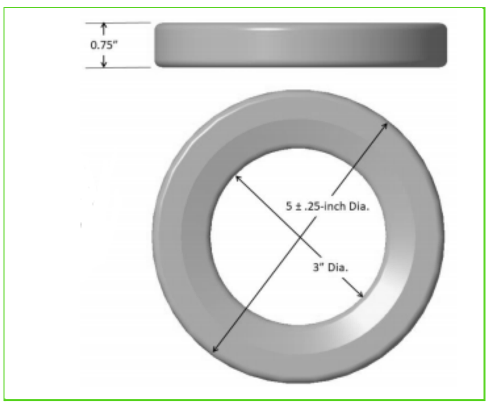


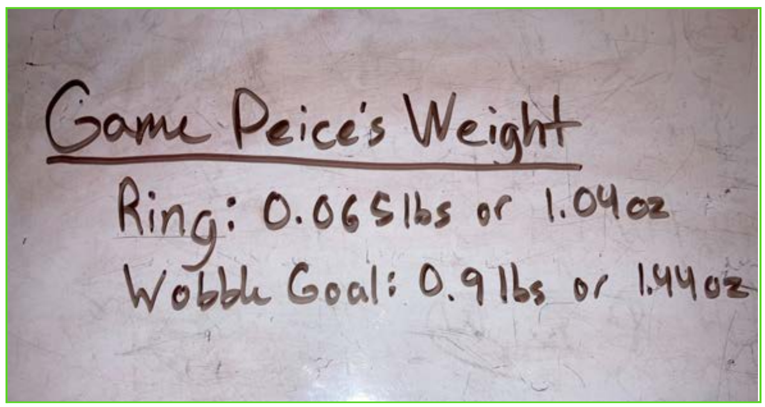
DESIGN PROCESS IN ACTION

(1) DECOMPOSE CHALLENGE TASKS, (2) CONDUCT POINT ANALYSIS

For the first two portions of our design process, we looked at all the ways to score on a computer screen, and created a chart comparing the point values. We went through each one, clarifying the task and reading the rules. We also went through field and game piece dimensions and weights.







IMPORTANT RULES
Robots can only control 3 rings at a time
Robots can only control 1 wobble goal at a time
Rings must touch floor before robot can interact
Robot must be in launch zone before shooting

HIGHEST SCORING ACHIEVEMENTS
Wobble Goal deliveries (15-20 pts)
Power shots (15 pts)
High Goal shots (12 pts)

TELE-OP SCORING ACHIEVEMENT	DIFFICULTY (1-10)	PERCENTAGE OF TEAMS TO ATTEMPT
Rings in Low Goal	3	20%
Rings in Medium Goal	6	10%
Rings in High Goal	7	70%

(3) IDENTIFY GOALS: SEE PAGE 8

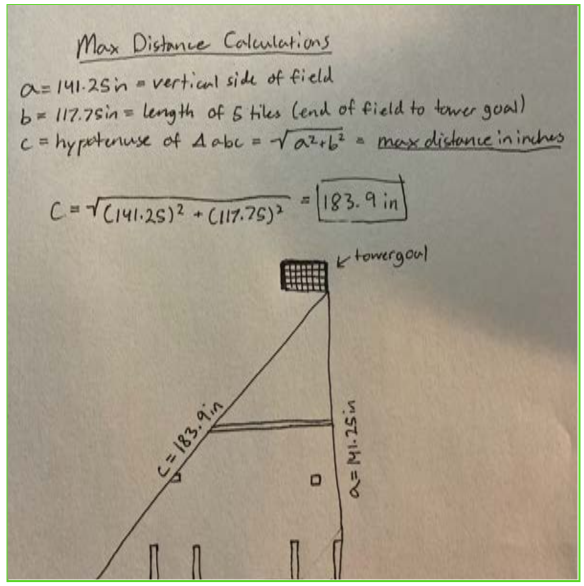
MECHANISM SPOTLIGHT: 180° SHOOTER

(4) SPECIFY SOLUTION REQUIREMENTS

For our shooter mechanism, we wanted to make sure that we were able to outtake the rings as quickly, efficiently, and accurately as possible. We went through many steps to accomplish this.

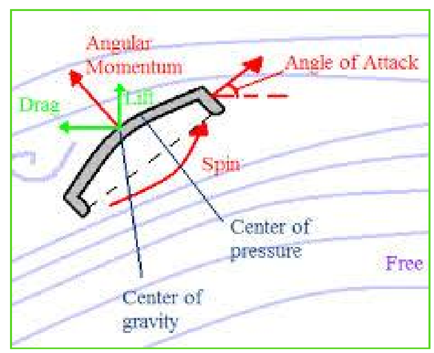
SHOOTER REQUIREMENTS

- Must be able to shoot into high goal (33 in. off the ground)
- Must be able to shoot from a minimum distance of ~70.5 in. away from the tower goal
- Must be able to shoot from a maximum distance of ~183.9 in. away from the tower goal (back corner of the field opposite to our tower goal)
- Must be able to rapid fire, must be accurate to within 2 inches, and must make 8/8 shots



(5) RESEARCH

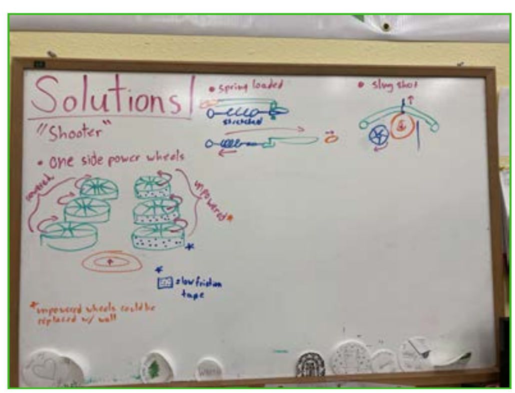
After listing our shooter's requirements, we decided to conduct some research to see what other teams had found to be successful while also complying to our requirements.



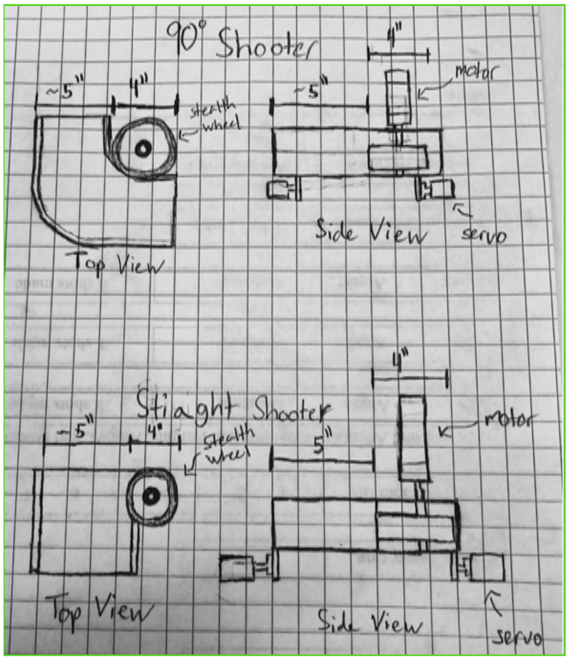
(5) LIST ALL IDEAS

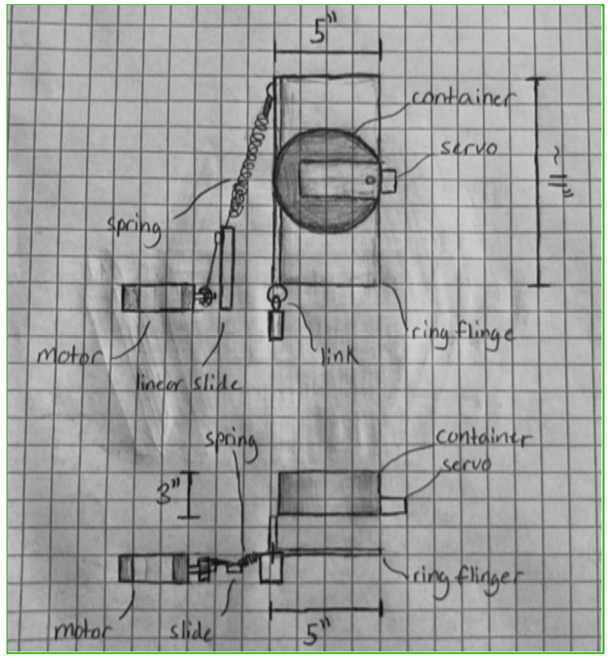
SHOOTER IDEAS

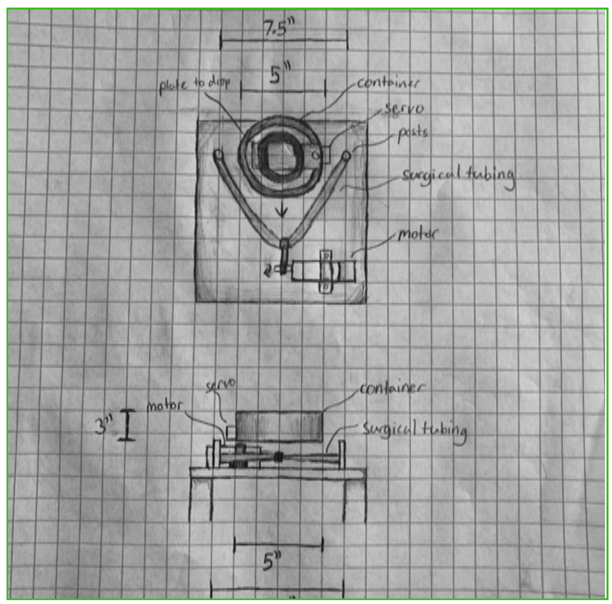
- One side of powered wheels
- Spring loaded
- Slingshot
- 90° Wraparound shooter



(6) SKETCH IDEAS, (7) PROS AND CONS, (8) PROTOTYPE







<u>PROS-CONS EXAMPLE: 90° SHOOTER</u>

PROS
1. Will be able to spin rings well (when in air) 2. Adjustable speed 3. Consistent if well tuned 4. Can shoot very rapidly
CONS

1. Possibly expensive
  a. May require two motors
2. Hard to tune
  a. If not tuned well, may be inconsistent

Through pros and cons lists, we narrowed down our design ideas to the 90° shooter, and slingshot. We began prototyping, and noticed the 90° shooter was a clear winner. Out of curiosity, we built a 180° shooter prototype and tested that; it was the best of the three!

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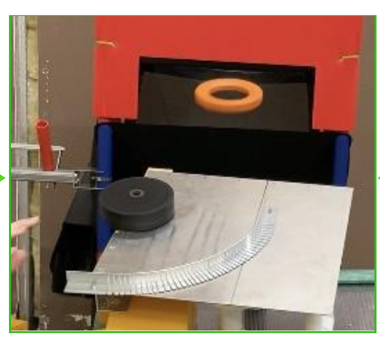

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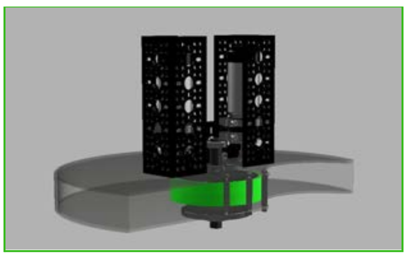
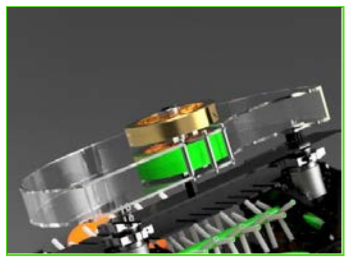
COLLECTED PROTOTYPE DATA

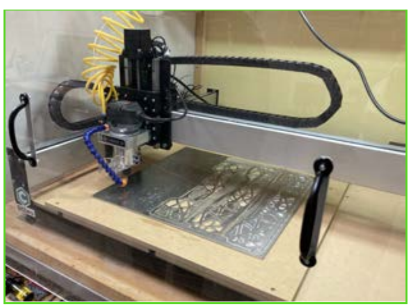
	180° SHOOTER	90° SHOOTER	SLINGSHOT
	Driver: 6,000 RPM	Driver: 6,000 RPM	N/A
SPEED PER RING (s)	>1	>1 s	1.2
ABILITY TO RAPID FIRE (-/10)	9/10	3/10	1/10
AVERAGE CONSISTENCY (-/8 SHOTS)	5.6/8	5.6/8	2.3/8
AVERAGE ACCURACY (IN. WITHIN TARGET)	4.2”	5.6”	23”

(9) CAD SELECTED IDEA

IMPORTANT LESSON: It is extremely important to include all screws in CAD or else there will be spacing and accessibility issues when assembling.


(10) ASSEMBLY



(11) TEST & COLLECT DATA, (12) ANALYZE, (13) IDENTIFY DEFICIENCIES

	180° SHOOTER
	Driver: 6,000 RPM
SPEED PER RING (s)	>1
ABILITY TO RAPID FIRE (-/10)	8/10
AVERAGE CONSISTENCY (-/8 SHOTS)	7/8
AVERAGE ACCURACY (IN. WITHIN TARGET)	1”

ANALYSIS

- 180º shooter is very fast and accurate
- It meets rapid fire and accuracy requirements

DEFICIENCIES

- Consistency issues, due to battery, inconsistent ring feeding, and lack of inertia

SOLUTIONS

- More weight on 3D printed inertia wheel
- Redo hopper for more consistent ring feeding
- Run the shooter on setVelocity() with encoders

ROBOTICS ENGINEERING | MATH & SCIENCE (4/26 EXAMPLES)

SHOOTER GENERAL BALLISTIC PROBLEM: CONCEPT INTRODUCED BY AEROSPACE ENGINEER COACH LISA

Change in y-position = y-velocity * time

$\Delta y = y_f - y_0 = V_y T$

$T = (y_f - y_0) / V_y$

$T = (y_f - y_0) / (V\cos\theta)$

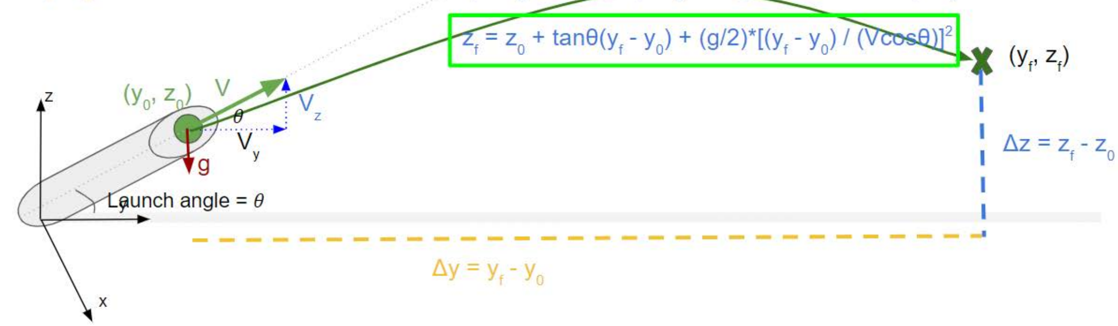
Change in z- position

$z_f = z_0 + V_{z0}T + (a/2)*T^2$

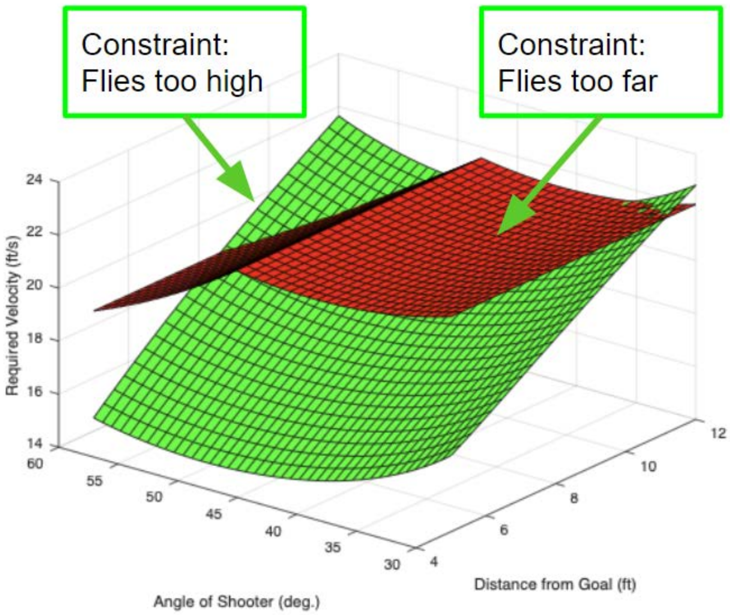
$a = g \quad Vz0 = V\sin\theta$

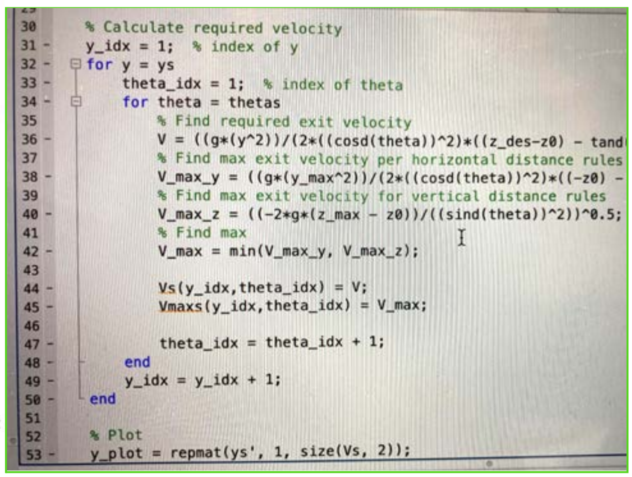
$z_f = z_0 + V\sin\theta[(y_f - y_0) / (V\cos\theta)] + (g/2)*[(y_f - y_0) / (V\cos\theta)]^2$

$\boxed{z_f = z_0 + \tan\theta(y_f - y_0) + (g/2)*[(y_f - y_0) / (V\cos\theta)]^2}$



SHOOTER MATLAB CALCULATIONS





```
% Calculate required velocity
y_idx = 1;  % index of y
for y = ys
    theta_idx = 1;  % index of theta
    for theta = thetas
        % Find required exit velocity
        V = ((g*(y^2))/(2*((cosd(theta))^2)*((z_des-z0) - tand(
        % Find max exit velocity per horizontal distance rules
        V_max_y = ((g*(y_max^2))/(2*((cosd(theta))^2)*((-z0) -
        % Find max exit velocity for vertical distance rules
        V_max_z = ((-2*g*(z_max - z0))/((sind(theta))^2))^0.5;
        % Find max
        V_max = min(V_max_y, V_max_z);

        Vs(y_idx,theta_idx) = V;
        Vmaxs(y_idx,theta_idx) = V_max;

        theta_idx = theta_idx + 1;
    end
    y_idx = y_idx + 1;
end

% Plot
y_plot = repmat(ys', 1, size(Vs, 2));
```

MATLAB code containing physics math

SHOOTER CONCEPTS: CONCEPTS INTRODUCED BY RESEARCH ENGINEER MENTOR RENZO & MECHANICAL ENGINEER DANA

INERTIA WHEEL	IMPORTANCE OF SPIN ON RING
$L = mvr$ L = angular momentum, m = mass, r = radius $\omega = \Delta\theta/\Delta t$ $\quad\omega$= angular velocity $\Delta\theta$= change in angular velocity, Δt = change in time $I = L/\omega$ I = rotational inertia	Any spinning object will have the tendency to stay stable on its spinning plane due to angular momentum. $L = mvr$ L = angular momentum, m = mass, r = radius