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

FTC TEAM 16265 ENIGMA

2021-2022 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 8 students. One of our students has experience with FLL, five in FTC, and three in FRC. Three of our team members are new to the program. We also currently have 2 coaches and 2 mentors. 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 by focusing 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*

TEAM HISTORY | 2019-2021

WHAT HAVE WE ACCOMPLISHED?

1. **(2x) Winning Alliance of NM State**
2. **Winning Alliance of AZ State Saguaro Division**
3. **Invited to Maryland Tech Invitational at John Hopkins University**
4. **1st place Inspire at first qualifier**
5. **18 total awards**
6. **Fundraised over $17,000**
7. **Over 500 hours of outreach**
8. **Over 1,100 Instagram followers**

← **2019-2020**

← **2020-2021**

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 the 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.

INDIVIDUAL & TEAM BUILDING

MISSION

To form a strong, sustainable team and to grow as individuals going into a world of technology and business

ACTIONS

- 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

MISSION

To spread the impact, mission, and life changing effects of FIRST throughout New Mexico and beyond.

ACTIONS

- 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

MISSION

To build a competitive robot and to learn about real world engineering and problem solving.

ACTIONS

- 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 | PRACTICE ROBOT

The **practice robot** is a new thing we decided to try this year. This is a simpler robot designed and built entirely by our younger, less experienced, members. It is for the purpose of learning the ins and outs of what goes into building a competition bot, without the stress and pressure of having it ready to compete. Older students guide them in design strategies they can implement. They learn how to safely use tools, design mechanisms, problem-solve, and code with blocks. We will also be able to use this robot at outreach events instead of possibly risking damage to our field robot.

INDIVIDUAL & TEAM BUILDING | MEET THE TEAM

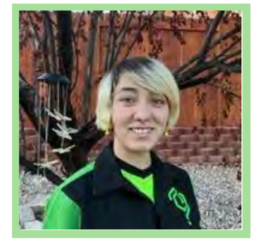
Each season, our members choose what **leadership positions** and **teams** they are interested in. We then all work together to accomplish our goals!

NAME: Isabel **AGE:** 17 **EXP:** 5

Team Captain, Electrical & Code Lead, Fundraising & Outreach Lead, Secretary, Managerial Team

NAME: Madelene **AGE:** 19 **EXP:** 6

Safety Captain, Team Spirit Lead, Managerial Lead, Build Team, Media Team, Pit Crew



NAME: Felix **AGE:** 16 **EXP:** 2

Build Lead, Pit Crew

NAME: Gray **AGE:** 16 **EXP:** 2

Treasurer, Game Manual Specialist, Build Team (CAD), Managerial Team, Fundraising & Outreach Team,
Pit Crew

NAME: Dimitri **AGE:** 11 **EXP:** 0

Photographer & Videographer, Scout Team, Build Team, Team Spirit & Media Team,

NAME: Andres **AGE:** 13 **EXP:** 0

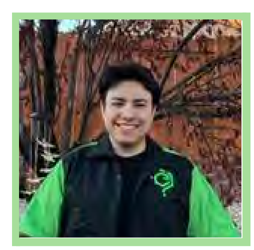
Photographer & Videographer, Scout Team, Build Team,

NAME: Luke **AGE:** 13 **EXP:** 0

Scout Team, Build Team

NAME: Tazz **AGE:** 17 **EXP:** 3

Managerial Team, Scout Team, Media Lead



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 • Many tools and expensive machinery • Not opposed to change	• Lack of workspace (besides garage) • Lack of mentors • Lack of engineering connections
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 & place at worlds	• 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

2021-22 SEASON	2022-23 OFF SEASON	BEYOND
FORM AT LEAST 3 REALLY MEANINGFUL CONNECTIONS WITH THE LOCAL ENGINEERING COMMUNITY		STEADILY INCREASE FIRST GROWTH IN NM BY OVER 15%
ADD TO THE WEBSITE AND YOUTUBE CHANNEL		GROW OUR NON PROFIT INTO A RESOURCE FOR FIRST TEAMS IN NM
FUNDRAISE OVER $8,000	FORM & MENTOR 2 MORE FTC TEAMS IN NM	INTRODUCE UNDERPRIVILEGED NM STUDENTS TO FIRST
HIGHEST SCORING TEAM AT A TOURNAMENT	BUILD AN OUTREACH AND PROGRAMMING ROBOT	SEE FIRST PROGRAMS IN EVERY NM SCHOOL
QUALIFY FOR NM STATE	HOST OUR OWN ROBOTICS SUMMER CAMP	SEE 2+ NM TEAMS REPRESENTED AT WORLDS
PLACE IN OR WIN INSPIRE	INCREASE OUR FUNDING BY 25%	

GOAL ACTIONS: 3 EXAMPLES

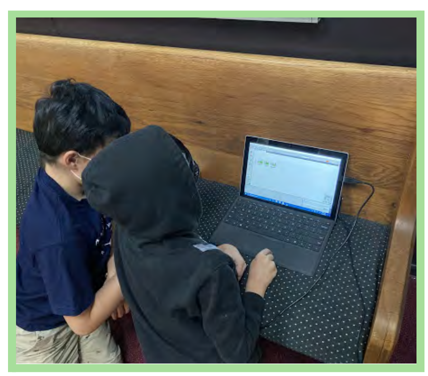
THREE MEANINGFUL ENGINEERING CONNECTIONS	OUTREACH & FUNDRAISING TEAM	• Research local engineering companies and events for possible opportunities • Brainstorm what a meaningful interaction/relationship would look like
ADD TO THE WEBSITE AND YOUTUBE CHANNEL	TEAM LOOK/MEDIA TEAM	• Brainstorm ideas for 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

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>

9 FLL CLASSES

We have taught two seven-week FLL classes this season at Abundant Homes and Parent Led Academic Network Team. Students were split up into teams of three 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.



SHARING RESOURCES WITHIN OUR COMMUNITY

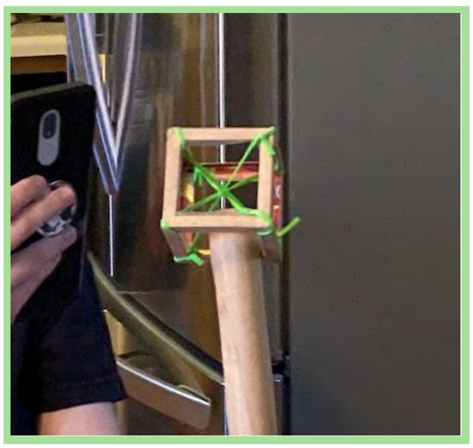
We think it's very important to share resources and to be as helpful as we can. This season, we have shared our team portfolio with other teams, reached out to smaller teams just getting started, and helped teams who have trouble with their bot at competitions. We of course also share our tools and knowledge at competitions past and future.

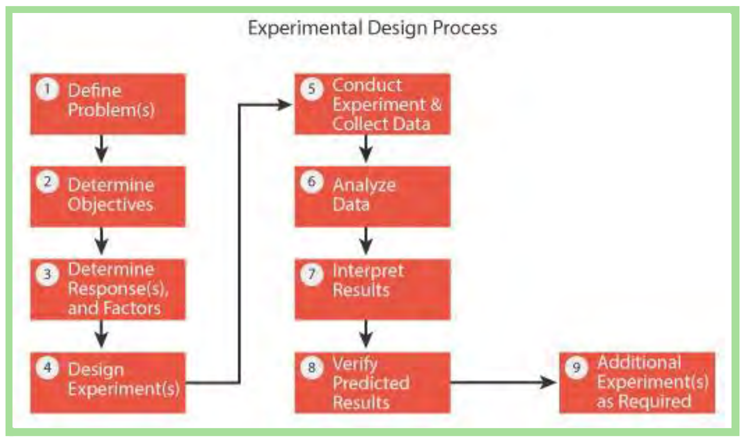
MENTORS | ENGINEERING CONNECTIONS

Mechanical Engineer | Research Engineer

MECHANICAL ENGINEER KIM

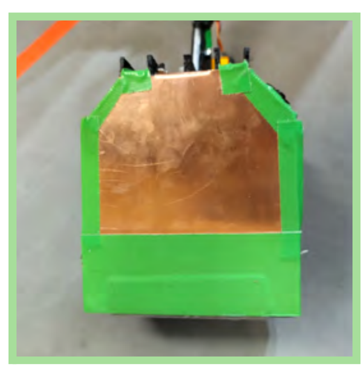
This season, Isabel recruited Kim as a mentor. She is a mechanical engineer at Sandia National Labs. Kim told us about how she inspects the quality of parts and the likelihood that they will work with her projects. She ensures that the parts that are manufactured are reproducible with minimal error. Kim told us about a process called design of experiments, which helped us prototype and test our team shipping element.





RESEARCH ENGINEER RENZO

We were also honored to have Renzo, a research engineer at Sandia National Labs with over 35 years of experience in energetic materials testing and over 6 years of experience with mentorship in the First Tech Challenge. Renzo has been a big help with overcoming severe issues this season. For example, this season our robot has had issues with ESD. Renzo pointed out that our box was dragging on the floor and basically acting like a capacitor, storing charge and then discharging in an instant, which would cause issues with our connectivity. To fix this, Renzo had suggested we fabricate a copper plate to attach to the bottom of the box which helps to prevent ESD.



ROBOTICS ENGINEERING | DESIGN STRATEGY & PROCESS

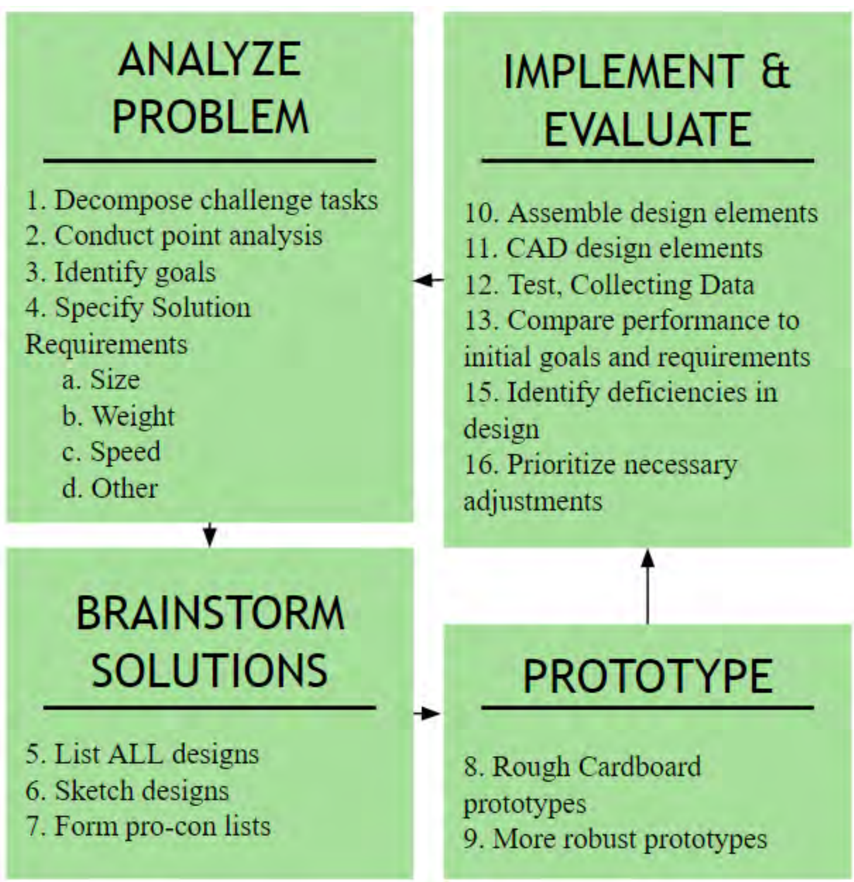
DESIGN STRATEGY

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 - CONTINUOUS PROCESS IMPROVEMENT



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. We went through each one, clarifying the task and reading the rules. We also went through field and game piece dimensions and weights. Here is what we identified:

IMPORTANT RULES
1. Robots can only control 1 freight at a time
2. Robots must be fully in the warehouse in order to collect freight
3. Robots must be fully outside of the warehouse and completely in the storage unit in order to score freight
4. Only one duck and team shipping element is allowed on the carousel at a time

HIGHEST SCORING ACHIEVEMENTS
● Unbalanced shared shipping hub (20 pts)
● Autonomous: Team shipping element on randomized level (20 pts)
● Capping team shipping element (15 pts)

TELE-OP SCORING ACHIEVEMENT	DIFFICULTY (1-10)	PREDICTED PERCENTAGE OF TEAMS TO ATTEMPT
Freight on shipping hub level 1	3	40%
Freight on shipping hub level 2	9	5%
Feight on shipping hub level 3	8	55%

Game Pieces

CARGO (lbs)	FREIGHT (lbs)	DUCK (lbs)
0.029 lbs	0.114	0.047

(3) IDENTIFY GOALS

AUTONOMOUS	DRIVER CONTROLLED	END GAME	TOTAL
Max Solo Points: **47**	Solo Points: **48**	Solo Points: **87**	**182+**
Program One ● Deliver a duck ● Robot completely in warehouse ● Two additional freight on shipping hub ● Box on randomized level using team shipping element	● 12 freight on shared shipping hub	● Deliver 6 ducks ● Balance alliance shipping hub ● Unbalance shared shipping hub ● Park completely in warehouse ● Cap team shipping element	

(4) SPECIFY SOLUTION REQUIREMENTS (INTAKE EXAMPLE)

For our freight delivery mechanism, we wanted an arm that was able to securely carry both freight types while also being able to quickly and carefully place them in both sections.

INTAKE REQUIREMENTS

- Only pick up one freight at a time
- Ability to pick up freight from corner
- Ability to pick up capstone/shipping element
- Deliver freight and shipping element to catapult arm
- Rigid
- Pick up freight in less than 2 seconds
- Must be contained within 18” x 18” frame of robot

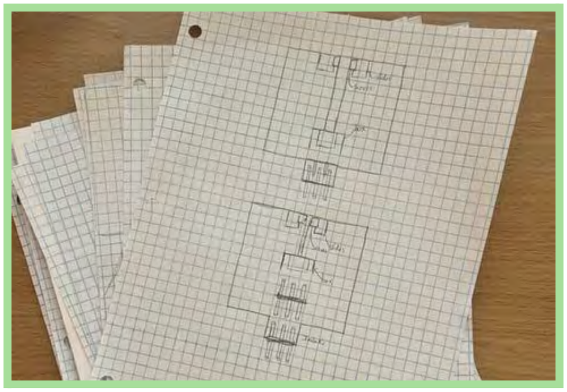
(5) LIST ALL IDEAS (INTAKE EXAMPLE)

We then make a list of all the possible mechanisms we could want to use and eliminate the ones that are less likely to offer success.

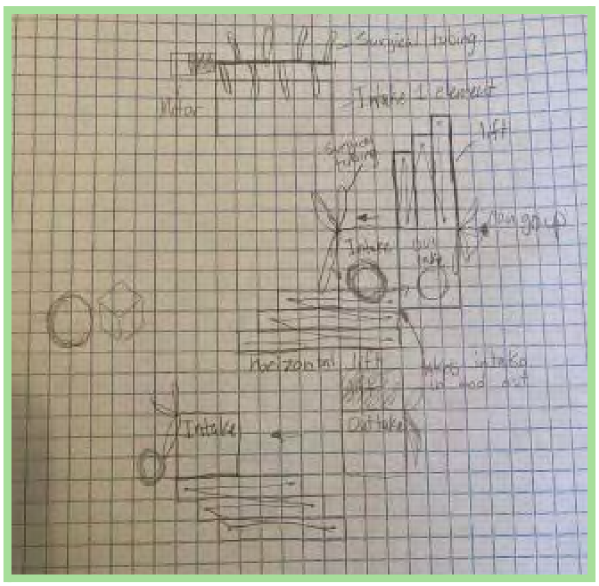
INTAKE IDEAS

Surgical Tubing
Surgical tubing attached to an axle that spins and intakes freight
Paddle Wheel
Compliance wheels with outside rubber cut off, attached to an axle that spins and intakes freight
Car Wash
Two rotating gears with compliant rubber bands that spin and intakes freight by squeezing it between them
Claw
Two pieces of plastic or aluminum attached to two gears controlled by one servo that clamp onto a freight

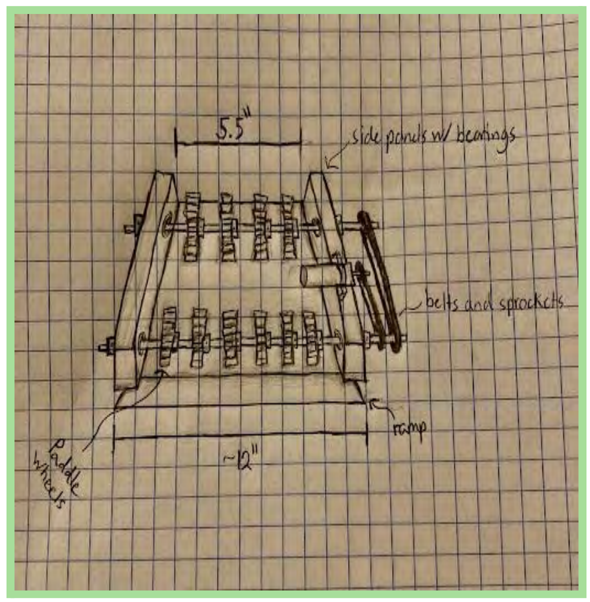
(6) SKETCH IDEAS (INTAKE EXAMPLE)



SURGICAL TUBING INTAKE



PADDLE WHEEL INTAKE



(7) PROS AND CONS LIST (INTAKE EXAMPLE)

INTAKE PROS AND CONS

Surgical Tubing
Fast, auto corrective, grippy, cost-effective, easier to tune | heavy & maybe bulky, susceptible to dirt

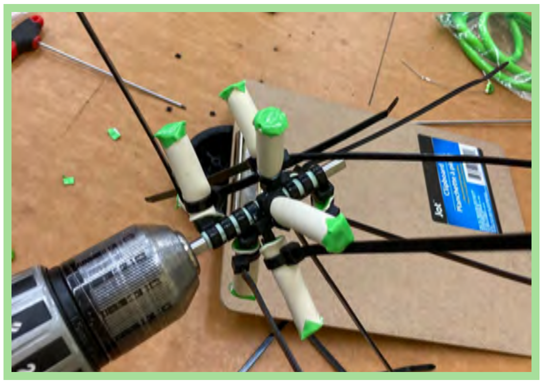
Paddle Wheel
Fast, auto corrective, grippy | bulky, not flexible, hard to tune, can be expensive

Car Wash
Grippy, more contact with freight | bulky, slow, complex, hard to tune, expensive

Claw
Lightweight, doesn't require motor or box to hold freight | Slow, complex, flimsy, can be expensive, possibly bulky, no auto aligning, hard to control, could break easy, hard to tune, servo draws more power

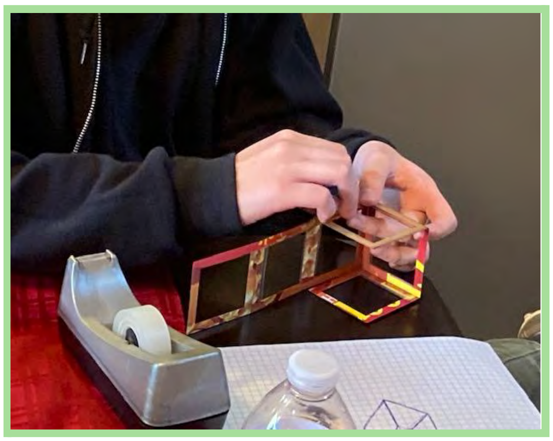
(8-9) PROTOTYPE (INTAKE EXAMPLE & MORE)

SURGICAL TUBING INTAKE PROTOTYPE

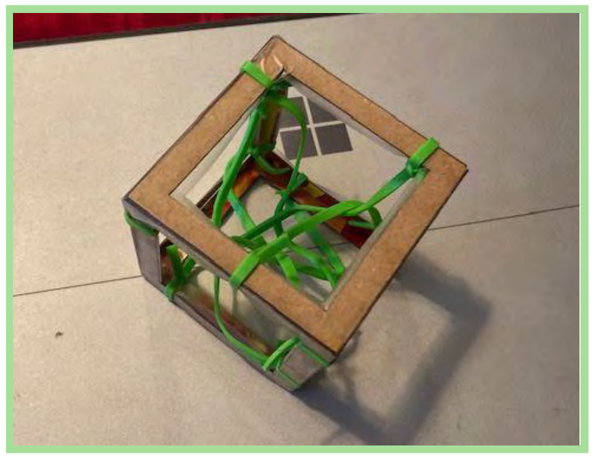


PADDLE WHEEL INTAKE PROTOTYPE

TEAM SHIPPING ELEMENT PROTOTYPE



FREIGHT BOX PROTOTYPE



<u>DESIGN DECISION</u>

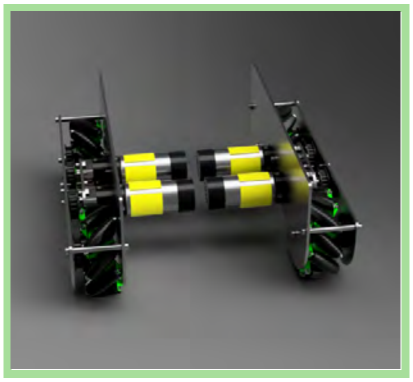
After prototyping some of our designs, we decided to go with a surgical tubing intake, which delivers freight into a box, ball-bearing slides driven by two linkages, and a "catapult" arm to deliver the freight. We also went with two compliance wheels attached to one another by belt pulleys to spin the carousel.

At this point in the design process, we have completed steps 1 through 9 for each mechanism on our robot. For the freight 'holder,' we decided upon a simple box with a rotating plate that acted as a claw. For the freight transferer (transfers freight from intake to shipping hub), we decided on a long arm driven by a servo, which acts as a catapult. In order to lift the catapult up to reach the top level of the shipping hub, we decided upon two linkages driven by servos. In order to spin the carousel, we decided upon two compliance wheels driven by one motor (belts and pulleys) that contact the edge of the carousel.

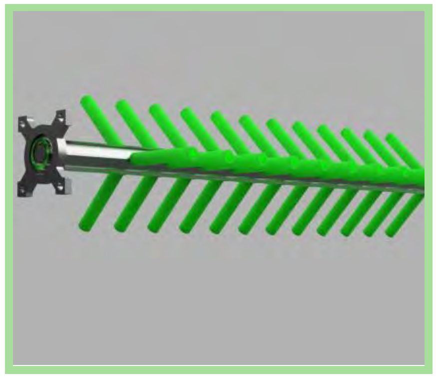
(10) CAD

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

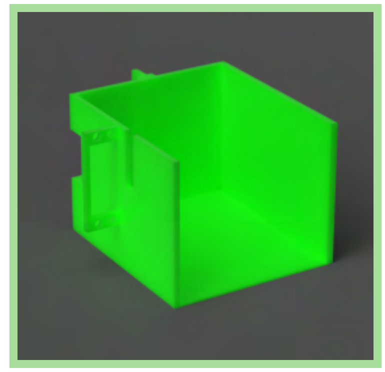
CHASSIS CAD



INTAKE CAD



FREIGHT BOX CAD



(11) ASSEMBLE DESIGN ELEMENTS

CHASSIS BEING MILLED

ORGANIZING SHOP

DIMITRI & DRILL PRESS

MADELENE & DREMEL

FELIX ASSEMBLING LIFTS

(12) TEST & COLLECT DATA, (13) COMPARE PERFORMANCE TO INITIAL GOALS & REQUIREMENTS, (14) IDENTIFY DEFICIENCIES (15) IDENTIFY SOLUTIONS

(INTAKE EXAMPLE)

INTAKE DATA	
SPEED PER FREIGHT (S)	> 4
# OF TIMES PICKED UP MORE THAN ONE FREIGHT (-/10)	4/10

TESTING INTAKE

ANALYSIS

- Able to pick up freight from corner
- Can pick up capstone/shipping element
- Delivers freight and shipping element to catapult arm
- Is rigid
- Is contained within 18" x 18" frame of robot

DEFICIENCIES

- Regularly picks up more than one freight
- Slow (takes more than 4 seconds to pick up freight)

SOLUTIONS

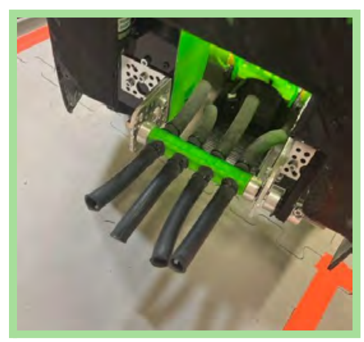
- Get grippier surgical tubing
- Change box so it can only hold one freight

After testing and analyzing our intake and other mechanisms, we decided to change the box so that more than one freight could not be obtained by the robot. We also bought grippier surgical tubing. The results of our changes are recorded below. We went through the same process for each mechanism and made the necessary adjustments. We can't wait to see how well our robot does at NM state; we're so proud of how far we've come so far this season with hopes to go further!

NEW BOX WITH GUIDES

OLD BOX

NEW SURGICAL TUBING



NEW INTAKE DATA

INTAKE DATA	
SPEED PER FREIGHT (S)	> 4
# OF TIMES PICKED UP MORE THAN ONE FREIGHT (-/10)	1/10

MATH AND SCIENCE BEHIND OUR DESIGN | SLIDES EXAMPLE

Ball Bearings Drawer Slides vs. Aluminum on Plastic Extrusion

Ball-bearing drawer slides are better than aluminum on plastic slides because they utilize ball bearings. Ball bearings dramatically reduce friction in rotary motion. The equation for kinetic friction, F_f, is the coefficient of kinetic friction, μ_k, times the normal force, F_n.

$$F_f = \mu \ F_n$$

Ball bearings reduce friction because they roll rather than slide, and when the balls are rolling, they almost always have a much lower coefficient of friction (on the order of 0.001 and referred to as rolling resistance with ball bearings; denoted by μ_r) than if two flat surfaces were sliding against one another (μ_k on the order of 0.3).