Exoplanet Explorers Transforming Space Technology

St. Ansgar High School - 2023

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Contest Theme:

Transforming Space Technology

Team theme:

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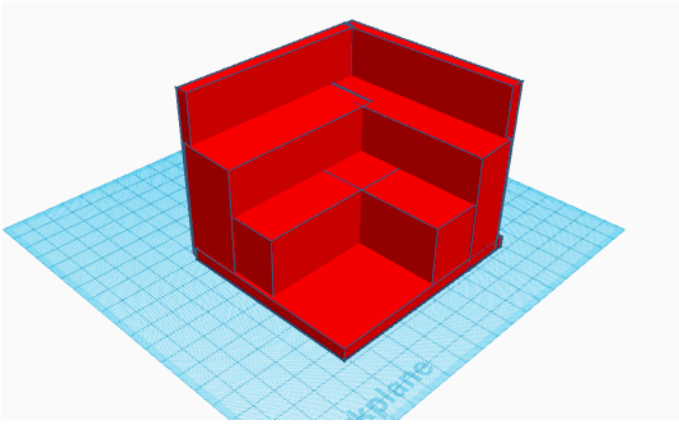
1. Initial Sketch, Plan of Design



Day 1: 11/20/22

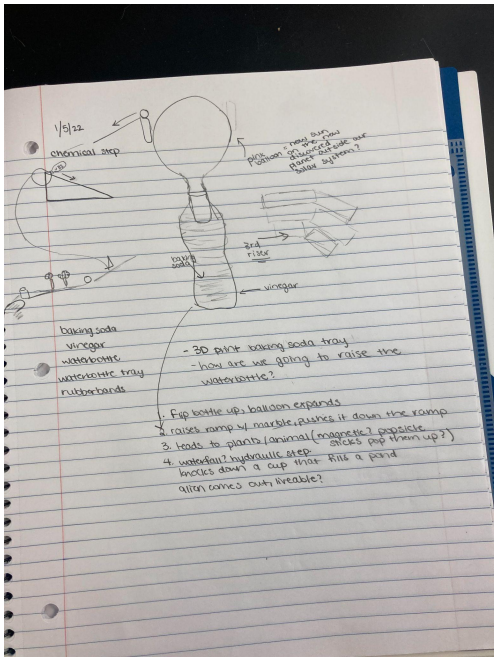
On the first day, we decided to use this wooden platform for a design because it would give us levels that would easily show the progression through the different planets and galaxies. However, we took out the bottom level square. We didn't really come up with the theme, but we researched space technology and how current missions are seeking to get more knowledge on our solar system.

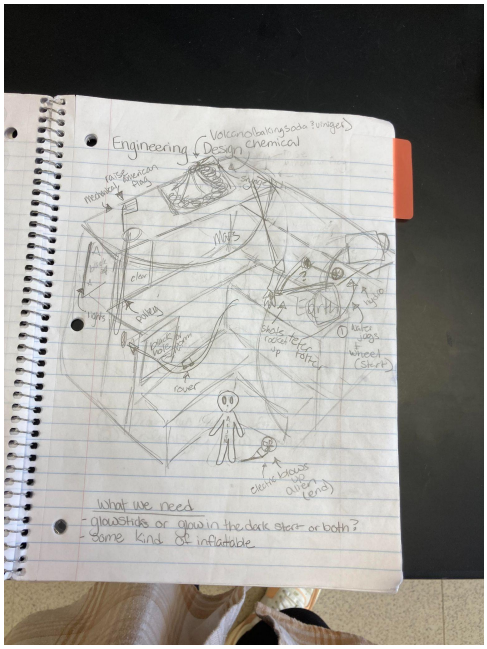
Day 2: 11/24/22

We had a question to ask ourselves. "How can we illustrate the idea of transforming space technology while using a machine that carries out that task?" We started imagining what that would look like and came up with the idea to explore and colonize new planets while cleaning up trash in our galaxy. Our ending goal was to find a new undiscovered planet with an alien and water, showing that it was capable of sustaining life. We were exploring outside of our solar system and at the same time improving our galaxy.

2. Classroom Work Day Progression

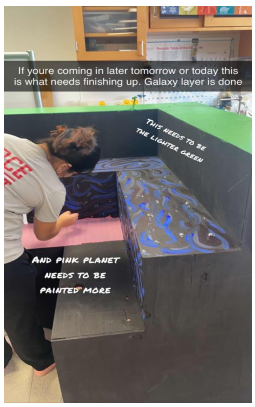
Day 3: 12/28/23 After our physics final, we were able to focus more on the project again. We started brainstorming ideas and planned out which category each couple would be in charge of. We figured that working in pairs would be well, since we could have someone researching and someone testing/ designing. We sketched ideas about what we wanted to have happen on each level.





Day 4: 1/4/23 We painted the whole wooden piece black, because we weren't sure which levels were going to be the galaxy, and we wanted to cover up the paint that was already on it.

Day 5: 1/8/23 We started painting more the levels. We decided that our top level was going to be the first planet, second layer the galaxy, and the third layer was going to be the newly discovered planet. We were going to colonize the first level planet that is green, and the last planet on the third level was going to have an inflatable alien.



Day 6: 1/12/23 We got more intricate with design and made the third level a pink planet designed to have the look of Jupiter. We painted the vines later to illustrate photosynthesis with the balloon being the sun, the jugs of water, and the green plantlife.

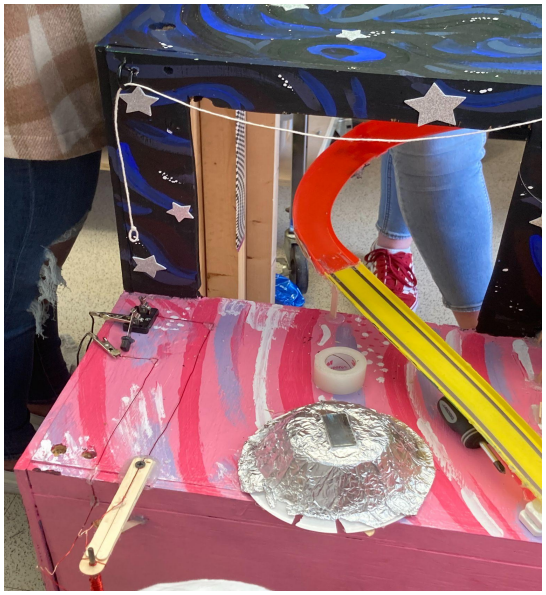
Day 7: 1/14/23: We started inserting some of the steps on the top including a rod for our flag step and people that stand up when a weight is dropped. After the painting was done, our ideas started being created and coming to life.

Day 8: 1/16/23: We made the top level more complex by adding a scissors step to cut the string that drops the weight into the tin can.

Day 9: 1/19/23

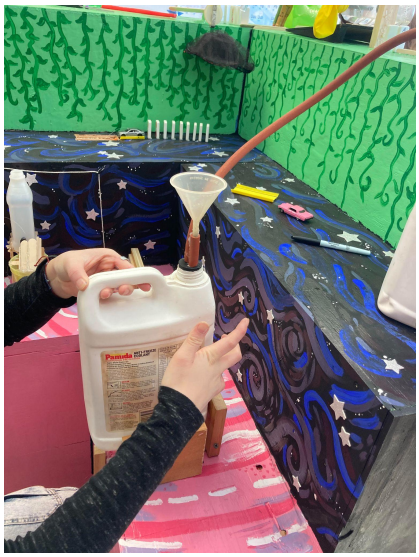
Today we installed a ramp that would come out the back of the machine to represent a wormhole in which one theory is that it begins with a black hole and ends in a theoretical white hole. The ramp stops and lets the car drop, opening the hole of the jug.

Day 10: 1/23/23 Finished the electro-magnetic step that uses a circuit that gets turned on to drop the UFO.

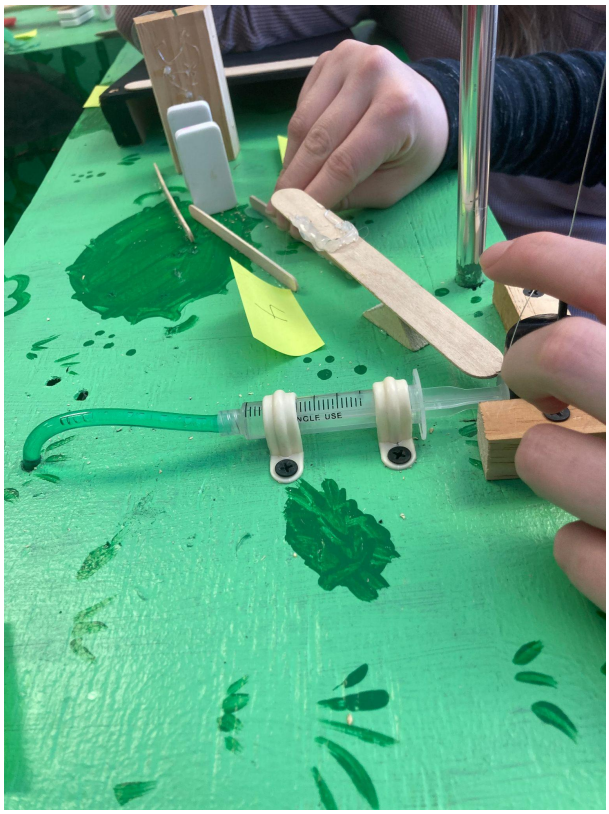


Day 11: 1/25/23 Made a pulley system on the top of the tower that gets triggered when the ping pong ball hits the mousetrap. This hits the switch that turns on the electrical step.

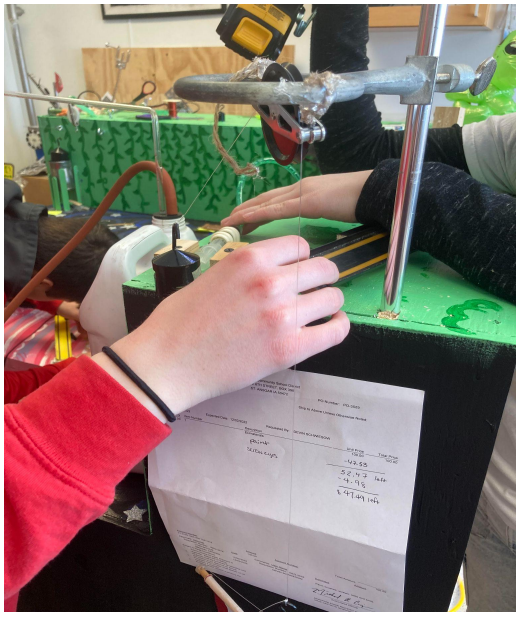
Day 12: 1/27/23 Had to keep adjusting the water jugs because sometimes they do and sometimes they don't work. We put more vaseline on the syringe to make it move easier.



Day 13: 1/29/23 Kept testing the machine to see what areas had kinks in it. We had some problems with the marble going off the edge of the table and not hitting the dominos correctly. We had to find a different marble to use and put glue more on the popsicle stick.



Day 14: 1/31/23 Made a way for the cup to stay on the third level without it tipping off the ledge and spilling the water. We ended up unscrewing all the nails and the pole and moving it over. This would allow for a bigger ramp, making dominos step a lot more accurate. We had to make a lot of improvements to this project, especially with the water jugs. We also had to alter our wooden ball with the flag, at first it was a marble but we realized that it didn't have enough power to knock the dominos consistently.



3. Finished Project

https://youtu.be/Hy_cSBwbvl4

4. Written/Numbered Steps

Step 1. A team member fills the jug on the bottom which has a hose attached to the one on the level above. The air pressure goes through the tube and forces the water through the straw; the water is then emptied back into the funnel. The water weight added causes the syringe it's sitting on, to be forced down, which brings about the next step.
Step 2. Two syringes are connected with a small hose; the whole contraption contains water. As the syringe is forced down, the water forces the other syringe to extend, pushing a weight over the edge of the ledge.
Step 3. The weight is attached to the flag, which is raised because the pulley system on the top is triggered.
Step 4. The flag pushes the wooden ball down the ramp that runs into the dominoes to start a chain reaction.
Step 5. The dominos hit a wooden block that knocks the water bottle down the ramp..
Step 6. The balloon and water bottle filled with vinegar are pushed down the ramp that has baking soda on the ledge inside. Once it goes down the ramp, the baking soda is able to make a reaction, causing the balloon to blow up.
Step 7. The balloon at its fullest is able to hit the next set of dominos.
Step 8. The dominos push a golf ball down a ramp.
Step 9. The golf ball is stopped at the end, pushing a weight off the edge.
Step 10. After the weight is pushed off, this makes the scissors cut a string, which then sends a heavier weight down into the tin can.
Step 11. The weight opens a closed pin. The string from the close pin goes through a pulley system and drops the net. This traps the 'space trash' on the bottom. The net has a weight inside which makes it heavy enough to push the dominos down.
Step 12. The dominos are knocked down, hitting the toy car. This makes the car go down the ramp.
Step 13. The car goes down the ramp and has a string tied to it that is attached to a plug in the mini water tower.
Step 14. With the gravitational pull, the plug is released. This sends the water jutting into the cup.
Step 15. The ping pong ball is sent floating up due to the buoyancy, and then the ping pong ball rolls down the ramp, hitting the mouse trap.
Step 16. The Mousetrap is triggered and this turns off the electrical system.
Step 17. The electromagnet is now turned off, and this drops the styrofoam bowl "UFO."
Step 18. The styrofoam bowl lands on a switch on the bottom that blows up an alien, using a hair dryer, ending the project.

5.Material Log

ITEM	QUANTITY	ORIGIN	PRICE
Base from previous projects	1	Reused	$0.00
Acrylic paint	7	Hardware store	**$47.53**
Blow up alien/ packs of stars	3	Amazon	**$45.60**
Ping pong balls	2	Mr. S	$0.00
Small American flag	1	Mr. S	$0.00
Car ramps	4	Mr. S	$0.00
Toy car	1	Mr. S	$0.00
Fishing line	1 roll	Mr. S	$0.00
Popsicle Sticks	120	Khari	$0.00
Syringe	2	Mr. S	$0.00
Weights	4	Mr. S	$0.00
Wood blocks	2	Mr. S	$0.00
Tin can	1	Mr. S	$0.00
Dominos	21	Mr.S	$0.00
Pulley System	3	Mr. S	$0.00
Plastic jug	2	Mr. S	$0.00
Pair of scissors	2	Mr. S	$0.00
1000mL graduated cylinder	1	Mr. S	$0.00
Metal rod	1	Mr. S	$0.00
Wooden ramp	1	Mr. S	$0.00
Golf ball	1	Mr. S	$0.00
Toy people	3	Mr. S	$0.00
Hair nets	5	Kwik Star	$0.00
Circuit switch	3	Mr. S	$0.00
Mousetrap	1	Mr. S	$0.00

Plastic cup	1	Mr. S	$0.00
Gatorade bottle	1	Recycle bin	$0.00
Hair dryer	1	Khari	$0.00
Hot glue sticks	90	Mr. S	$0.00
Hot glue guns	3	Mr. S	$0.00
Wiring & switches	2	Mr. S	$0.00
Fairy lights	1 string	Mr. S	$0.00
Batteries	3	Mr. S	$0.00
Wooden ball	1	Mr. S	$0.00
Vinegar	1 gallon	Mr. S	$0.00
Baking Soda	1 box	Mr. S	$0.00
Paper towels	1 roll	Mr. S	$0.00
Paint brushes	10	Mr. Nielsen	$0.00
Costumes	7	Ourselves	$0.00
Vaseline	1	Lucy	$0.00
Plastic tub	1	Mr. S	$0.00
Large Alien Costume	1	Amazon	$49.95
9 volt batteries	10	Hardware Store	$17.99

Recycled Materials Used:

Total Number: 319
Recycled Materials: 309
Percent Recycled: 96.9%

6. Successes & Challenges

Challenges

A big problem we had at the beginning was getting the concept of the theme. We had an idea at the beginning but after thinking about it harder, it did not fulfill the prompt. We also had a hard time coming up with ideas and making them come to life. However, after getting our brain juices flowing, our ideas started becoming a reality and we pulled together to make some really cool steps in our project!

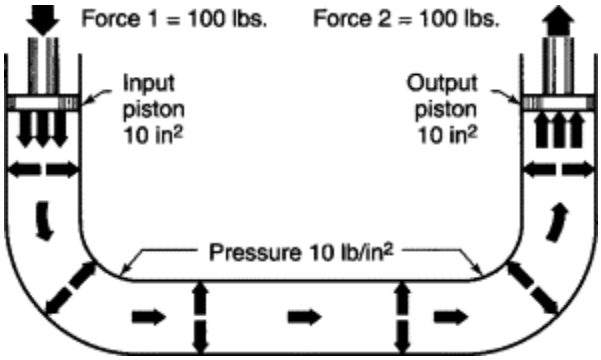
Successes

We are all pretty busy with sports, jobs, and extracurricular activities. This made it a little challenging and we had to start fitting times in during seminars and on weekends to get the project to come together. We didn't start as soon as we should have, but with the little time that we had, we put together something awesome and we are very proud of the hard work that we have put in.

7. Advanced Components

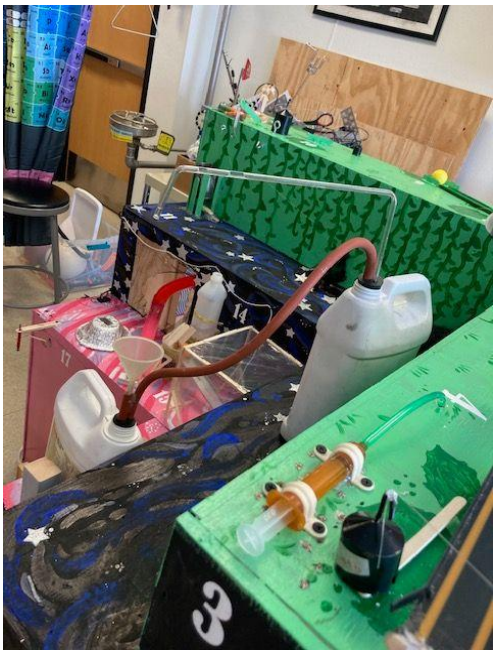
Hydraulic Steps: Step #1 & #2

- Hydraulics: The two jugs are connected with one rubber tube. The filled jug is placed a step higher than the lower jug, which contains 145 mL of water. Both jugs are sealed with plugs whose only openings are for the connecting hose, the bent straw, and the tube connected to a funnel. This project starts with the pouring of water into the funnel. As the steady flow of water goes into the bottom jug, there's air pressure that gets displaced. The only way for it to escape is the tube connecting the two jugs. The air pressure is then forced into the top jug, forcing the water out of the straw, which then flows back into the funnel. The weight will increase as more water transfers from the top to the bottom jug. The bottom jug is lying atop a syringe and the added water weight forces the syringe downwards. Because this 5 mL syringe is connected to a 10 mL syringe with a hose, as the one side is forced down, the other will extend. This works because of Pascal's law: P = F/A. As force is downwardly exerted on the first syringe, that same force will push out on the second syringe: F1/A1 = F2 /A2. That second syringe will push a weight off the edge of the step, causing the pulley to let the weight fall and the flag to rise.



Challenges:

- In my opinion, this step was one of the hardest to perfect. Our first struggle was that the jug balanced on the syringe was tipping over. Since the bottom of the jug also has an inverted dip, we knew we needed to create a way to achieve consistent balance.
- Once the walls were set up, we came upon another problem: overcoming static friction. Once the syringe overcame the initial force pushing against it, the kinetic friction was easy to overcome, but the static friction was still an issue. The wooden walls we made were causing too much friction to the sides of the jug. We spent hours slightly changing the position of the bottom jug to see if we could balance it well enough so it wouldn't catch on the sides. Because the board was sitting on the syringe coming out from a hole in the project, it was still higher than usual, and the center of gravity was hard to determine. The original walls we made were too short to hold the jug stable.



- For a majority of the trials we went through, the biggest problem was how long it took to overcome static friction. The gradual water weight added didn't have enough force to conquer it in an adequate time. The first half of our many trials took over a minute to win the battle with the static friction. We experimented with multiple sizes of syringes, testing how much weight it took to overcome the different levels of friction.

Resolution:

- We then engineered pole-like structures into the base, to reduce overall friction, as well as to keep the jug from tipping. We also used Vaseline to help reduce the static friction.
- To have a more sturdy jug, we lifted it, and glued a popsicle stick to the bottom, creating a perpendicular X, so one variable of this process could be eliminated.
- The walls we started with were 4"x 5" boards. Because they were so wide, they were creating extra friction, and we came to the conclusion that thinner, taller pieces of wood reduced the friction and held the jug steady.
- Lots of trial and error led us to find that a 10 mL syringe on the top, and 5 mL syringe on the bottom, worked the most efficiently for our project.

Chemical Step: Step #5 and #6

- There is a water bottle filled with 80mL of vinegar on top of the ramp. Inside the cap of the bottle is a little tray that hold ≈ 2 tablespoons of baking soda. When the dominoes knock the bottle down the ramp, the baking soda on the tray drops down into the pool of vinegar. This triggers the reaction which fills the balloon with gas.

Chemical Reaction:

Reactants:

- Baking soda (Sodium Bicarbonate) ($NaHCO_3$)
- Vinegar (Acetic Acid) ($HC_2H_3O_2$)

Products:

- Carbon Dioxide (CO_2)
- Water (H_2O)
- Sodium Acetate ($NaC_2H_3O_2$)

Chemical Equation:

$NaHCO_3(s) + HC_2H_3O_2(l) \rightarrow NaC_2H_3O_2\,(aq) + CO_2\,(g) + H_2O\,(l)$

Challenges:

- We got the balloon to blow up with the right ratio, but we didn't know how to slow the balloon down so that it would blow up enough to be significantly large before moving onto the next steps. The dominos needed to be tipped over by the balloon in order to start the next step. We also had issues with it tipping the dominos over in the same direction every time, not in the direction they were supposed to go. We tweaked the first part of the ramp that leads into the dominos before the balloon is hit to make it more accurate.

Resolutions:

- To combat this problem of not having enough time to react, we made a stopper with popsicle sticks to stop the bottle from rolling. For the dominos, we made a popsicle stick track for it to roll on every time without fail. Originally, we had thought to put the balloon vertically, and allow the contents to be spilled to the bottom. However, that was a hard task to make happen vertically tipping it up.

Mechanical Step: Step # 10

Mechanics

- The weight is hanging by a fishing line which is tied on both ends. This has gravitational potential energy. With the 1000-gram weight, it has a large amount of stored energy. As soon as the line is cut, this gravitational potential energy is converted into kinetic energy. This energy is transferred first to the can as it weighs it down, and also to the people tied with the fishing line and the clip holding the line connected to the net.
- Through this process, there are input and output forces acting on each of the people. The input forces are through where the string is tied and the output force is either the head or torso area, depending on the location of the input force. The outer two people are third-class levers and the middle one is a second-class lever. Using the 1000 g weight proves to be a great mechanical advantage as it goes from the people, through the line, to the can in which the weight is dropped.

Challenges

- One of the biggest challenges with this step was getting the weight and the strings in the correct positions. The fishing line tied by the toy people determines where the tin can sits. If these lines are too long, the can will already be sitting on the clip, and once the weight falls, the people will not pop up because the string is still slack. On the other hand, if the string is too short, the people will pop up, but once the weight is dropped, the can will not reach the clip, releasing the net.
- Another challenge that we ran into while working on this step was the string not releasing/getting stuck in the clip and the net not falling, not falling fast enough, or not knocking the dominos down.
- In addition to this, we also had trouble making the people pop up because some of them had looser joints than others.

Resolution

- In order to resolve the problems previously stated, we used trial and error in reaching the right length for the fishing line. This does not have to be replaced after each run, so we are confident that it will always stay at the correct length.

- We overcame the issue of the clip not releasing the next line by making sure the string was placed at the low point of a ridge in the clip. This ensures that when the clip is open, the string can freely slide, releasing the net, and at the correct speed.
- The last challenge was the net not consistently knocking the dominos down. Our net itself was very light, so we first added a styrofoam bowl to the inside, this made the transition into the next step smoother, but still not as consistent as we would have hoped. We then added a small weight to the inside of the bowl, which is just enough to make it move faster when falling, but not too much that it will fall out of the clip and pulley system.
- To fix the inconsistency in the toys popping up, we tied the fishing line around the neck instead of the ankle. This changed the input and output forces to a different area of the toy but allowed it to pop up in the same way as the others, despite the difference in their joints.

Electrical Steps: Steps #16, #17 & #18

The mouse trap is loaded with potential energy. Once the mouse trap is set off due to the collision caused by the ping pong ball, the trap pulls a string tied to the switch. This switch completes the circuit of electrical current. Once the circuit is broken, the electromagnet is turned off. The electromagnet caused a magnetic field because of the many wraps of wire around it. Both ends of the screw then become magnetic as a result of the wrapped wire with an electric current. When the current is broken, gravity then accelerates the 'ufo' toward the ground. The 'ufo' then lands on a power strip that is connected to the hair dryer. The hair dryer forces air into the blowup alien to conclude the presentation.

Challenges

- One challenge that was faced during step #16 was getting the ball to float in the water and then roll down the ramp. This was essential because the ball needed to roll down the ramp to trigger the mouse trap. While experimenting with the floating ping pong ball, at first it would not get up and over the lip of the cup. Another part of this challenge was getting the water

with such a powerful stream from the water tower to all drain into the cup. If any water misses the cup, it could land on the wires on step #17 and short-circuit the electrical circuit.

- Another challenge that occurred was trying to get the power strip to switch when the 'ufo' landed on it. The switch only clicked once around 4.5 Newtons of pressure were applied. The falling 'ufo' had nowhere near the amount of kinetic energy to trigger the switch.

Resolution

- To solve the first challenge, it was found that with the flow of water being used, one ping pong ball was not going to be able to float over the edge of the cup. Using one ball would also require water to overflow over the edge of the cup. To solve this problem another ping pong ball was added to the cup. This allowed for the lower ping pong ball to push upwards on the upper ping pong ball. When the water was added to the cup, the bottom ping pong ball floats upward which causes the upper ping pong ball to tip over the edge of the cup and down the ramp without spilling any water over the edge.
- The second challenge was solved by constructing a weight to add pressure to the switch before the 'ufo' landed on it. This design was made by using a pea-tree dish with two 200g weights on it. Stabilized by popsicle sticks, this contraption was able to add enough force to the switch that the switch would only trigger when the 'ufo' would land on it and not before.

8. Reflections on the Process

Maci: I was unsure of what I could contribute to this project when first knowing our objective. When all of the hands-on work started, I quickly was immersed in this project. I thought this project was really unique because it makes you problem-solve in creative ways. I really enjoyed how our team worked together to solve the issues we were facing. It was stressful at times when others had really cool steps but it was hard to connect them to each other. I personally struggled with our chemical step and how we were going to trigger the step for it to work. Watching all of the steps succeed was extremely satisfying in the end. All and all, I thought this project was an amazing experience. In the future, I can apply my problem solving skills that I learned in all facets of my life. Collaboration and conflict will always go hand-and-hand, and knowing how to resolve issues that arise will help me greatly in my future endeavors. Moving forward with this project, I think we can improve our journal to make it more clear about the operations of the machine. I also think we should perfect our hydraulic step to make it consistent and lead to the next steps every time.

Mikhail: I learned many things by contributing to this project. I love to think outside of the box to solve problems and to work under stress. With the project put off longer than it should've been, some parts of my steps were cutting it close to being completed on time. This made it fun because of all the adrenaline when working for long periods of time to get the steps done. I also enjoyed working with a great group of people. The teamwork that occurred during this project was phenomenal. Many ideas were shared which enabled so much success. I thought it was very interesting how critical the scientific method is in order to solve problems. Overall the project was a great experience and being able to apply the physics learned in class to real-life situations was fun and rewarding. A real-life situation includes teamwork skills, more specifically communication. Communication in a team is a vital part, and my communication was greatly tested and improved during this project. To continue perfecting our project, I think we need to make our beginning water step work perfectly every time. We also need to perfect our journal in order to make our only chance of lost points from our actual project. Moving forward I think taking advantage of each other's strengths is going to be necessary to perfect our project.

Madi: I found this project very challenging. I really had to think about all of the steps a lot, especially the scissors. That part of the project took me the longest because it was hard to set up, and it really taught me how important trial and error is because it helped make that step a success in the end. I enjoyed getting to work on steps with other people because it was easier to bounce ideas off of each other than just working on something by yourself. I am glad that I got to be a part of this project. The things I have learned while competing with this team will help me in my college career and after. I have become a better problem solver, team leader, and most importantly, I have become a better student. I've learned to use the scientific method to the best of my abilities to help in all aspects of learning, not just in science-related classes. After our first competition, we learned what we really need to

perfect. Some of those things include making sure the water step becomes more reliable and consistent. We also need to have members of our group get their parts memorized for the presentation more and we need to make sure our journal is 100% and can get as many points for us as possible.

Khari: This project has taken a lot of problem-solving and thinking outside the box. When I've seen Engineer and Design projects in the past, they've always seemed so hard and stressful to do. They're a lot of work, but it is fun to see your ideas come to life. The frustration and trial runs were hard to deal with at times, but in the end, I'm glad that our steps didn't work in the beginning and then work in the end versus working in the beginning and not at the competition. This project was definitely worth it, even if I didn't enjoy every part of it. I'm glad that I got to participate in this cool experience and learned a lot throughout the process. Something I will take away from this project in my adult life is how important it is to work together. You won't always agree on decisions, but it is vital to have the desire to win or achieve something as a group in order to get past your disagreements and get what you want done. To improve our project before April, I think we need to polish up our journal, memorize our presentation better, and perfect the water step.

Addi: This project was a challenge for me. It really makes me have to think out of the box to come up with ideas that would work well for the project. It was hard to continue to keep trying when things didn't go as planned. It was hard to keep the mindset that you have to push through and keep working at it in order for it to work. We had a lot of trial and error which was hard, but after adjusting some things on the project we were able to get it. This project has taught me that when you have people that all have the same goal in mind, you will find a way to put all the ideas together to reach the goal. This project will help me in the future when I have to work with others and problem solve. This project really showed me that when you work together as a group, you will come up with different ideas that will help the group. This will help me because I need to get better at working with people and communicating my thoughts. Overall, I really enjoyed working on this project because it has taught me how to work together with my classmates and was fun to see the project come together and succeed. To improve this project, we need to perfect our hydraulic step. We need to figure out a way to make it more consistent.

Lucy: This project was very mentally challenging for me. Because physics isn't my natural forte, I found it difficult to put myself in a mindset to keep trying. When things didn't go as planned, I wanted to give up. In order to reset my thinking, every hour or so, I had to sit down and take a few deep breaths; the whole trial-and-error process was not easy to deal with. I found that when I focused on my team, and how much work we had already put into the project, it gave me the motivation to push forward. I enjoyed bonding with my teammates as we worked hard and together until the very end. As a team, we learned so much about how to put our skills into practice, and how to work together toward a common goal. This real-life experience increased my capacity to work as a team in the future.

Jessie: I really enjoyed being a part of this group and being able to work on this project. I've never done anything like this before, so it definitely required a new type of critical thinking for me. Dealing with these types of hands-on projects truly helped in understanding physics and the world around us. We put lots of time and effort into this project, taking away from homework time or other activities, but in the end, it was well worth it, and we have learned so much from this experience. Following the completion of this project, I had more knowledge in the field of physics in relation to mechanics, hydraulics, chemical, and electrical. Along with this was an advancement in the understanding and importance of teamwork. In the future, I can use this to support teams I am working with, and to provide ideas and bring them to life using my knowledge of these components along with the STEM process. Following our project, one area I believe we can improve on is efficiency. Our hydraulic step has been pretty unpredictable throughout the whole project. Through doing more tests and extra adjustments we can fix this issue to make our project run smoother each time.

Bibliography

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