Pius XI Catholic High School

Engineering Machine Design Contest

2022

Members: Kim Albright, Jenna Barwick, Ellie Baudry, Casey Brophey, Samantha Christian, Raul De Jesus, Katie Mendez, Drew Miler, Zach Nowak, Murphy Roszak, Elise Sepulveda, Gabe Spellman

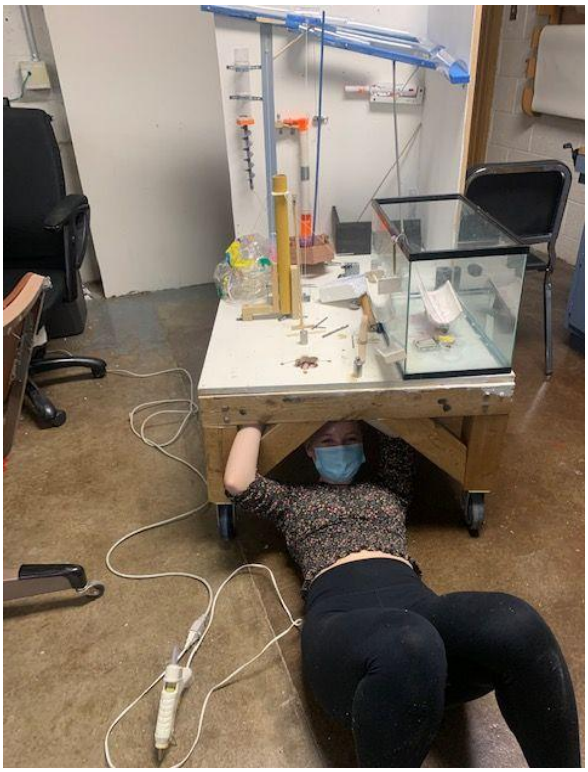
Teacher: Cathy Zurawski

Progress Photo

Building the bases and painting.

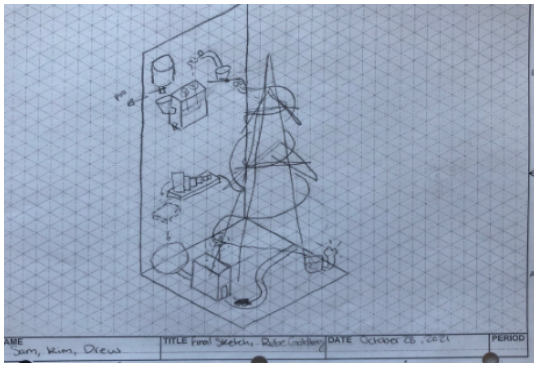
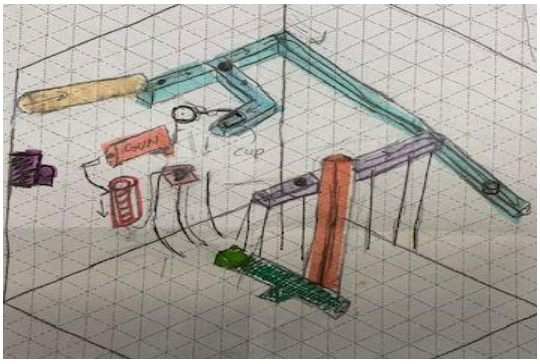
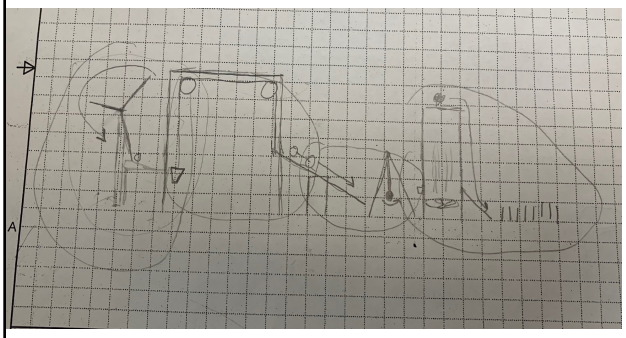
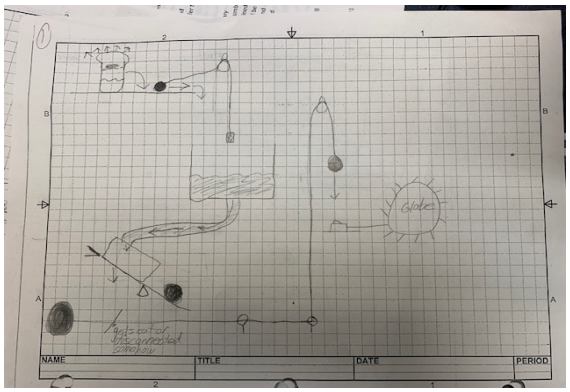
Steps are in the process from being transferred from the practice boards to the base.

Getting steps on the board and testing the chemical reaction.



Finishing up final touches.

1.) Initial Sketch and Descriptions

	After combining ideas and building our power towers out of popsicle sticks we ran into a number of challenges. The towers were smaller in real life so two were necessary to support our marble track. The "light switch" starting step took a long time to design and complete and even broke a few times in the process. The "zip-line" (replacing a ramp) was troublesome until we added the double string to balance the weight. However, the most prevalent challenge was the fluid power. The original idea was a domino landing on an airbag that transfers air to push a toy car. We struggled to design a strong enough bag, so we moved on to a recycled pump. This, however, required too much force for our large domino. Our final idea came to the domino landing on a platform that pushes a syringe attached by a tube to another syringe. We were able to manipulate this platform and arm enough so that the domino has just enough force to activate our fluid power step. We ended up abandoning the toy car in favor of marble to better bridge into the next group.
	Our first change was switching the initial stretch of tubing to a wooden ramp instead. This was to accommodate a larger ball size. The second change was reversing the second ramp to face the other way. This was done to better trigger the gun because it ended up being longer than we thought when drawing. The third improvement had to do with the length of the gun being longer than expected. We had to implement a pulley so the bullet would have to travel a smaller distance to trigger it. Overall most of the steps on the wall had to be shifted over to compensate for the large gun.
	For the original steps, the windmill hit a ball into a cup attached to a string. That string then lifted up a ramp releasing a car. That car then hit a pendulum into a button. That button then powered a fan lifting a ramp releasing a ball into dominoes. In the final, the windmill releases a ball down a ramp into a cup attached to a string. The string pulls a lever releasing an arm pushing a dart into flywheels. The dart then flies into a switch powering a motor, the motor then pulls a weight releasing a lever.
	We heavily changed our initial design through our building process. The only step that remained the same from start to finish was the ending, lighting up a globe.

Our Overall Design Process

We utilized the design process diligently in the making of our machine for the purposes of organization and efficiency.

Define a Problem

The main problem or task we are trying to solve was to create this complex machine to solve the simple task. We took the requirements from the competition and decided that our last step would be turning on a string of lights.

Generate Concepts

The way our team approached this was by dividing our board into quadrants and assigning teams to each section. We each created 3 different sketches with 4-5 steps. This was how we each brainstormed.

Develop a Solution

We then came together and combined ideas. After discussion and deliberation, we worked on preliminary final sketches. From those two final ones we discussed which option would be best and from there we shifted our focus to starting to create and plan for our final sketch.

Construct Prototype

Each team had a quadrant of the board so we each focused on our 4 steps. This was the majority of our process as we did individual testing on each of our boards and ran tests to check the efficiency. At the end of January collectively we had an efficiency rate of 93%.

Construct Prototype Part 2

We then had to create transition steps. Although we had gotten each quadrant to function, we had to connect each group's steps. We took one person from each group to work on each transition step.

Evaluate Solutions

The final way we used the engineering design process was when revising. We had to make many improvements and alterations in order to make the whole board function.

3.) Written Description & Final Machine Design Image:

In our machine design, we wished to incorporate various different types of energy production, transportation, storage, and usage. Visible components of this element of our design include the battery dominos, the coal mine, the electrical towers, and lightning. Our starting step resembles a light switch being turned on and our machine run ends with a string of lights inside a transparent globe being lit up or "Lighting Up the Globe", our spin on this year's theme of "Power the World."

4.) Machine Steps:

1. A ‘light switch’ is flipped, opening a water valve, which causes water to be dumped into a container, allowing a foam platform to rise.

2. The rising platform causes a zipline to be released, knocking a marble down a tube.

3. The marble knocks over a row of dominos, causing a large domino to fall onto a platform.

4. The platform lowers, causing a syringe attached to a tube to compress, which causes another syringe on the opposite end of the tube to extend, knocking a marble down a tube, which falls into a cup.

5. A marble drops into a cup weighing down the windmill blade causing it to turn, releasing a ball bearing down a ramp.

6. The ball bearing lands in a cup attached to a string, when the cup gets weighed down, the string pulls a release lever.

7. When the release lever gets pulled upwards, an arm swings forward with a toy dart attached, punching the dart into spinning flywheels, propelling the dart into a switch.

8. The switch powers a motor, pulling a weight off of a lever with another weight on the other side as a counterbalance, the lever then swings down, pulling a string that releases a marble.

9. Marble #1 rolls down an inclined plane hitting the lever. Lever guides marble #1 around the turn to hit larger metal ball #2. Larger metal ball #2 contact weight causing it to fall off the inclined plane.

10. The weight attached to the trigger pin gets released from the toy gun trigger. The toy gun triggers foam bullets. The toy gun bullet is attached to a string along with a pin for screws. When the toy gun bullet is released it rotates on the pulley pulling the screw pinout.

11. When the screw pin is released the screw drops down, causing the popsicle stick to fall. Releasing a spring causes a ball to drop down through the tube.

12. The ball hits the wedge, wedging the lever, causing the other side to drop.

13. Marble is released by the movement of balsa wood causing the ball to go through the entire track.

14. Metal ball bearing knocks overweight which pulls stick out from the lighting cup. The weight inside the cup pushes a syringe down.

15. Water dissolves powder mixture which allows a bouncy ball to roll down the ramp and hit the mousetrap.

16. When the mousetrap gets triggered, a pin is pulled which releases a metal ball bearing that rolls down the ramps.

17. The metal ball bearing pushes a stick on an axel which knocks over weight, the weight has a string attached and on the other end is a piece of wood that pulls out from under another weight which is located in a tube.

18. The weight falls and hits a button.

19. The button is pressed which turns on a strip of lights in a globe, completing the final task of powering the world.

5.) Machine Cost & Percent of Recycled Materials Used:

Group 1	Group 2	Group 3	Group 4
Recycled	Recycled	Recycled	Recycled
Wipe container Wood Scrap plastic Scrap pipe String Marbles Paint Waterproof paint Duct tape Weights Pulley wheels Fluid power kit	Toy flywheel Toy truck Toy jolt Packing peanuts Marble Yogurt cup Lever switch Cardboard & cardboard cylinder Wood Weights Rubber bands 9-volt batteries	Clear plastic tubing Wood Disassembled parts from a toy gun Pulley Paracord Auger from a fondue fountain 3-D model screw base 2-pound weight Scrap wood PVC pipe Rubber bands Toy car	Can Fish tank Mousetrap Portable charger Fairy lights Bouncy ball Syringe Scrap wood Scrap pipe pieces
Purchased	Purchased	Purchased	Purchased
Popsicle sticks ($8) Bendable tube ($10) Turkey baster ($1.25) Funnel ($1.25)		Popsicle sticks $0.50	Citric Acid $25 Baking Soda $1 Beach Ball $2.50

Base Materials

Recycled

- Wheels

Purchased

- Particle Board and 2x4 wood planks $110

Total Cost of Machine $159.50

85% Of machine is Recycled Materials
15% Purchased Materials

6.) Success & Challenges

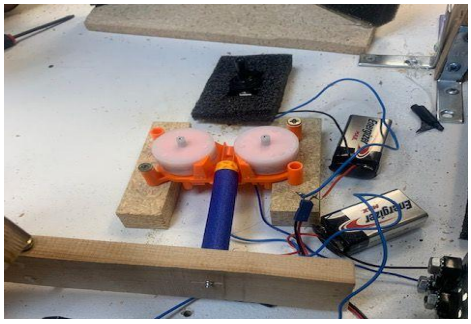
Challenges

As we were testing our machine, the metal ball bearing fell off the track into the glass fish tank. This caused a setback in testing, having to stop working for the day and clean that up and then start over with fixing the tank and reassembling everything.
We had multiple attempts at incorporating fluid power. We originally sketched a balloon being pushed down by weight and as the balloon deflates the air blows a car to initiate the next step. When we started building we found a pump that we tried using but it created too much pressure and was unable to be reworked. We brainstormed various ideas including what we currently have on the board which is a syringe lever system, where a domino falls onto a platform that pushes down on one side of a syringe that is connected to another syringe to push a marble down a ramp.

Successes

Our first complete run was on 2/27 and only needed 1 intervention.
Successfully soldered a circuit. A mini circuit board was connected to flywheels from a toy gun to a 9-volt battery.
One of the biggest struggles was the presentation. As a group, we felt overwhelmed at first and because of this, we began to express and feel a lot of stress as the competition day came closer. This challenge was unique because we brought it upon ourselves. Despite this though, we recognized our mistakes and were able to overcome this challenge, so in the end, we were able to write a script we were proud of.

7.) Advanced Step Component

Chemical (Casey, Jenna, Elise): The advanced component is a chemical reaction between sodium bicarbonate and citric acid triggered by water resulting in the conversion to carbon dioxide gas and a sodium citrate-water solution which allows a ball placed in the mixture to be released and fall on the mousetrap.	
Electrical (Zach and Raul): The advanced component is a flywheel from a toy gun. We made an arm that holds a toy dart and is pushed into the flywheel to shoot a switch that activates gears that pull on a string that pulls the weight.	
Fluid Power (Drew, Kim, Samantha): The advanced component is a syringe system. A domino lands on a platform, compressing a syringe. The fluid in the first syringe is pushed to the second syringe which extends the plunger, pushing a marble down a tube.	
Mechanical (Katie, Gabe, Ellie, Murphy): The Advanced component in our group was a screw and the wedge. The **screw** was set off by a pin and triggered a popsicle pulling out of a spring. The **wedge** begins by being pushed by a metal ball and from that triggers the lever.	

8.) Reflection

Casey	My group was tasked with the chemical reaction advanced component for the machine. I had to do lots of research into potential chemicals and reactions we could utilize in our steps and this research revitalized my interest in chemistry and led me to look into majoring in chemical engineering in college.
Ellie	By being a part of this team I have learned many things. I have learned collaboration, teamwork, tenacity, and problem-solving. Working with a team has taught me valuable life skills of group work along with personal discovery. Overcoming challenges and finding new solutions.
Elise	This experience has shown my strength and weakness, allowing me to understand more about myself. I've learned that I enjoy the design aspects and dislike the long hours of fine-tuning.
Murphy	During the first couple of weeks, it didn't seem like it was going to be as fun as I had hoped because we were just drawing and planning but once we started bringing our ideas to life this class exceeded my expectations. The joy you get after iterating through countless modifications and the component finally working is amazing. Overall my experience with this team was amazing and I will definitely be back next year to compete.
Zach	Since joining this team, I've been able to put skills I've learned years prior, like soldering, to use, and learn how to work simultaneously with others efficiently.
Sam	Participating in this project has taught me the value of other people's contributions in my own work. It has also rekindled my love for problem-solving, and I now can't imagine a future that doesn't involve it in some way. I've also learned how to better collaborate on something small–which is essential in an engineering career.
Drew	Being a part of this engineering team has taught me the design process as well as the importance of teamwork. During the construction process of the machine, there were multiple instances when a problem arose and I had to use the design process to create a solution to that problem. The light switch valve system, zipline, and fluid power system were all designed by my teammates and me with the design process. My teammates have shown me the value of being a team. On our team, everyone has had a role to follow that has all been very crucial. Finally, everyone on our team has learned that working together is important to succeed.
Katie	When it comes to a future career, I don't know what I want to do. I do know, though, that I have a great passion for engineering and the process of designing and constructing a machine such as ours. Through being on this team, I have learned more about what it takes to work as a team, not just being stuck together for some small group project for a class I don't enjoy. This project has introduced me to new ideas, how to consider others' ideas, and truly strive for a successful end result. As with my unsure future, I am sure that I will be able to use my newfound skills to figure out my future.

Word Count: 2,499

Bibliography

Bonuccelli, Courtney. “Reaction Exposed: The Big Chill! - Activity.” *TeachEngineering.org*, 8 Mar. 2022, https://www.teachengineering.org/activities/view/wsu_big_chill_activity1. Accessed date January 15, 2021.

“Fossil.” *Energy.gov*, https://www.energy.gov/science-innovation/energy-sources/fossil. Accessed date October 21, 2021.

Sarah. “Easy Homemade Bath Bomb Recipe.” *Home* -, 2 Jan. 2022, https://www.feastforafraction.com/diy-bath-bomb-recipe/. Accessed date November 7, 2021.

“What Is Fluid Power?” *What Is Fluid Power?*, https://www.nfpa.com/home/About-NFPA/What-is-Fluid-Power.htm#:~:text=Fluid%20power%20is%20a%20term,gas%20(usually%20compressed%20air). Accessed date December 12, 2021.