Superheroes Powering the World St. Ansgar High School



Team Members:

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Contest Theme:

Power the World

Team Theme: Superheroes Powering the World

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1. Initial Sketch and Description of Machine Design Planned

Day 1: 11/4/21

On the first day, we decided how we want our base to look and how big we want it. We chose this style because we thought we could use the different levels to connect different steps. We designed a 3D model, shown to the right, of what we want the base to look like. We brainstormed ideas for a team theme. We did not come up with any ideas for the theme or the chemical, fluid, mechanical, or electrical step. Possible Dimensions: <u>Base</u> 4.5ft x 4.5ft <u>First level</u> 3.5ft



Day 2: 11/9/21

Second level 2.5ft Height 4.5ft

We did more brainstorming on the theme and decided on a theme we liked and the purpose of our project. Our project theme is superheroes powering the world. We're going to give hydroelectric power, solar power, wind power, and hydrogen power superhero names. Our project's end goal is to have these four "superheroes" power the world by lighting up the globe. We figured out possible steps for our chemical, fluid, mechanical, and electrical steps. The fluid step would have something to do with the base of our project holding water.



2. Process, Photos, and Work Days

Day 3: 11/17/21

Today we started taking apart an old construction of a previous engineering design machine to use the recycled wood for our base. We started to dismantle the original base to get an idea for the new base. We didn't get all of the class time to work, so this is what we accomplished.







Day 4: 11/19/21

Today we changed up our theme a little bit. Instead of four power sources, we decided that each one of us will choose a power source to research. We each picked a power source that we will create steps for and dress up as a superhero-related to our source. Jex will be doing nuclear power, Jaci has wind power, Lorne has biomass power, Trystan has geothermal power, Kennedy has hydroelectric power, and Emma has solar power.

We are planning on building the rest of the base during another workday when we have all of our materials. We found a clear ball with a globe inside that we can use in our project. We plan to put LED lights in the clear ball, and have them light up around the globe for our electrical step.





Day 5: 1/4/22

Today we finalized the structure of the base and made a list of materials needed to paint design. Our first plan is to paint the base white and once that dries, start sketching on a design to paint. We want the design to be a vision of a city skyline incorporating our 6 superheroes (6 energy sources). We're going to paint the base white on Wednesday and then sketch/paint the design on Thursday.

Day 6: 1/6/22

Today we figured out specific steps we will incorporate into our project. Everyone did research to create steps relevant to their superpower and figured out how to include those ideas in our

design. For example, some steps include a hydraulic press, a powered fish, and hot wheel cars. We figured how we want to paint our clear ball, and the lights we want inside of it. We used vinyl to put the outline of the continents on our ball to spray paint the ocean.

Today we're experimenting with our ideas. We have lots of ideas, so we are

Day 7: 1/12/22

putting our ideas together and seeing how they work. First, a few students spray painted the ocean part of our clear ball. For our city skyline, we painted the top layer black to represent outer space, the next layer is a green base like grass with a blue sky, and the next layer is a tan paint with sand on top to represent the beach. We started 3D printing a windmill model for our project. This windmill will represent wind energy.













Day 8: 1/17/22

Today we worked on the background for our base. We used vinyl stickers to create the designs, and then we transferred them onto our project. We did a few experiments to test our steps, some failed. Our chemical step fell off our base and broke on the ground, so we are brainstorming to prevent that from happening again.



Day 11 Today v chemic

Day 11: 1/27/22

Today we finalized our chemical step and put more steps together. With the chemical step, we struggled when it came to figuring out the ratio of baking soda to vinegar. We needed enough of a reaction in order for our next step to be completed. We completed our first 6 steps and are continuing to form more.

Day 12: 1/31/22

Today, we worked more on steps and perfecting our machine.

Day 13: 2/2/22

We got so much done today and we are nearing the end of workdays. We also need to touch up our journal.

Day 14: 2/3/22

We got a lot of steps accomplished today and only have a couple steps left. We are working on the finishing touches and making our project the best it can be!



<u>3. Final Machine Design</u>

Complete run-through: <u>https://photos.app.goo.gl/XLu5s8GtCzWkph5h7</u>



4. Written/Numbered List of Steps

Step 1: Team member releases the water bottle filled with vinegar down a ramp, causing the tray of baking soda to spill into the water bottle, inflating the balloon which lifts a ramp releasing the ping pong ball.

Step 2: The ping pong ball knocks over a set of dominos. The last domino pulls a popsicle stick to release another ball.

Step 3: Ball hits a connect piece to spin a peritrophic which hits another set of dominos. The last domino pulls a popsicle stick.

Step 4: Popsicle stick releases car and the car knocks the 400-gram weights off of the machine.

Step 5: The windmill spins, releasing the lever and causing the bowling ball to roll.

Step 6: The bowling ball hits the launch pad, causing the rocket to propel.

Step 7: The rocket hits the lever, causing the catapult to launch the marble.

Step 8: Marble rolls down a ramp, hitting a 100-gram weight

Step 9: Weight falls, releasing the Newtonian ball, and energy is transferred to the popsicle sticks which then hit the copper rod.

Step 10: Metal pellet falls down the copper rod, hitting two marbles in opposite directions.

Step 11: Marbles roll down the ramp, and hit a group of connects.

Step 12: The connects hit a 100-gram weight which then falls off the machine

Step 13: Weight pulls a string, closing the scissors cutting fishing line releasing a 1,000-gram weight.

Step 14: 1,000-gram weight falls on hydraulic press, which is our fluid step, lifting up a marble

Step 15: Marble rolls down two ramps, landing in a bucket. The bucket then removes popsicle stick releasing car down a ramp

Step 16: The car pulls a paper clip from a tube releasing water. The water falls onto a Robofish pushing it in the water.

Step 17: Fish swims away, pulling fishing line releases marbles

Step 18: Marbles roll down ramps and lands in a tin can, turning on the lights in the globe. (electrical step)

ITEM	QUANTITY	ORIGIN	PRICE
Base from previous project	1	Recycled	\$0.00
10ft 2x4s	2	Purchased	\$36.25
Screws	70-100	Industrial Tech and Mr.S	\$0.00
Painting Supplies	1	Purchased	\$43.49
White Paint (base coat)	1 can	Extra (last year)	\$0.00
Tarp	1	Recycled	\$0.00
Balck Mesh Screen	1	Recycled	\$0.00
Staples	80-100	Industrial Tech	\$0.00
Globe	1	Mr.S	\$0.00
Spray Paint	1 Can	Kennedy	\$0.00
Fairy Lights	1 Strand	Jex	\$0.00
Race Tracks	16	Mr.S	\$0.00
Weights	8 (all different masses)	Mr.S	\$0.00
Dominos	25	Mr.S	\$0.00
Rocket Launcher	1	Mr.S	\$0.00
Plastic Water Bottle	3	Recycled	\$0.00
Copper Tube	1	Mr.S	\$0.00
Cars	2	Mr.S	\$0.00
Metal Rods	3	Mr.S	\$0.00
Popsicle Sticks	100-150	Mr.S	\$0.00
Paper Towel Roll	2	Recycled	\$0.00
Plastic Tubes	3	Mr.S	\$0.00

5. Material Log

Connects	About 40	Mr.S	\$0.00
Newton Balls	1 set	Mr.S	\$0.00
Baking Soda	1 box	Mr.S	\$0.00
Vinegar	1 gallon	Mr.S	\$0.00
Fishing Line	1 spool	Mr.S	\$0.00
Balloons	15	Mr.S	\$0.00
Duct Tape	5 (not full rolls)	Mr.S	\$0.00
3D Printed Windmill	1	Mr.S	\$0.00
Ping Pong Ball	2	Kennedy	\$0.00
Marbles	6	Mr.S	\$0.00
Hot Glue Guns	4	Mr.S	\$0.00
Hot Glue Sticks	75	Mr.S	\$0.00
Scissors	1	Mr.S	\$0.00
Syringes	2	Mr.S	\$0.00
Robo Fish	2	Amazon	\$20.00
Clear Tub	1	Dollar General	\$14.97
Rubber Ball	1	Mr.S	\$0.00

Total Cost: \$114.71

Recycled Materials Used

Total Number: 484 Recycled Materials: 478 Percent Recycled: 98.8%

<u>6. Successes and Challenges</u>

<u>Successes</u>

One major success that we had when working on our machine was our teamwork. This whole engineering design process revolves around teamwork and our group had it. It did take a couple of days for everyone to find what their role in the project was, but once we did, we accomplished great things.



Challenges

We ran into quite a few challenges while working on this project. The first challenge we had to face was all of our busy schedules. We are all involved in so many extracurriculars that it was hard to find time for all of us to work. We solved this problem by going to work when we could. Another challenge that we faced was the indecisiveness of our group. Our group was very indecisive and often took longer than needed to make a decision. Once we realized that we needed to start making final decisions, we all stepped up in making decisions in order to take on that challenge.

7. Advanced Components

Chemical Step: Step #1

Chemical Reaction: Reactants: Baking Soda (Sodium Bicarbonate) NaHCO, Vinegar (Acetic Acid) HC₂H₃O₂ Products: Carbon Dioxide - CO, Water - H₂O Sodium Acetate . NaC₂H₃O₂ Chemical Equation: $\operatorname{NaHCO}_{3(s)}$ + $\operatorname{HC}_{2}\operatorname{H}_{3}\operatorname{O}_{2(l)} \rightarrow \operatorname{NaC}_{2}\operatorname{H}_{3}\operatorname{O}_{2(aq)}$ + $\operatorname{CO}_{2(g)}$ + $\operatorname{H}_{2}\operatorname{O}_{(l)}$

Challenges:

Our main challenge that we faced was that the balloon would inflate, but then flop to the side toward the ramp not allowing the popsicle stick to pull through releasing the ball. Since this is our starting step, we needed to make sure it worked seamlessly so our whole machine could run.

Resolutions:

In order to fix the flopping balloon, we actually totally changed our step to more of a ramp and lever component.

Here is our

re-constructed chemical step. The baking soda reaction happens inside the bottle inflating the balloon which then raises the ramping allowing the ping pong ball to fall and hit the dominos.



The stoichiometric calculation for the chemical step.



Fluid Step: Step #14

<u>Hydraulics:</u>

- $F_1/A_1 = F_2/A_2$

This equation represents the needed forces exerted on piston 1 to raise piston 2. The amount of force needed on piston one is determined by the areas of the two pistons. If piston one has a far less area than piston two, the force needed to lift piston two will be much less.

Challenges:

This fluid step came with many challenges to overcome.

- One of the biggest challenges was completing the connection from one syringe to the other without leaking water.
- Another big problem was creating enough force to overcome the inertia of the first piston

Resolutions:

After much time, each problem was solved.

- This problem was solved by finding a more secure hose that fit the syringes properly, rather than trying to tape then on.
- The second problem was solved by putting a weight on the 1st piston to help overcome the inertia it had.





Mechanical Step: Step #7

Mechanical Step:

First Class Lever

 Mechanical Advantage = din / dout = 3in / 6in = .5 This is how mechanical advantage is calculated with distance, in which the output arm has more advantage.

Mechanical Advantage = fout / fin = .0538N / 1.23N = .0437 N

- This is how mechanical advantage is calculated with force, which shows the input has more advantage.
- (Torquen = Torquesst) = (Firdin = Fourdow) = (1.23N x .0762m = .0538N x .1524m) = (.0938Nm = .00820Nm)

When I calculate for the torque, obviously the T_{in} and T_{out} aren't congruent because I used more force on the input arm. That's because I have to overcome the output arm to be able to launch the marble.

Challenges:

- One of the biggest challenges that I had was making sure the input weight was consistent when launching the catapult. The first input weight was too light and swung a lot.
- Another challenge I had to overcome was making sure the catapult was accurately shooting the marble onto the track.

Resolutions:

- To take care of the counterweight issues I had made a whole new counterweight entirely. I switched from a golf ball and metal ball, to using washers stacked on top of each other with a weight in the middle of them, and glued them all together.
- I took care of the accuracy issue by putting two supports on each side of the catapult since the frame was not strong enough on it's own

















<u>8. Reflections of Process</u>

Lorne: When we first were told about the engineering design project, I was a little bit overwhelmed. I was a little worried about finding time to work on the project, But I quickly realized that if I just put a little bit of time into it every day, it's not an impossible task at all. I have actually grown to like this project as it has made me have to think outside the box and think in ways I don't usually do at school. If there was one thing I had to take away from this, it's that no matter how confident you feel about having enough hot glue, you're wrong.

Trystan: One of the big things that I learned from this project is how much physics actually affects everything that happens. I learned to have appreciation for all of the engineers, because this was really challenging. I struggled a bit with trying to figure out what was needed to make the steps work together and make them consistent. Our teamwork was really good, which helped a lot with getting the steps to flow with each other. So the major thing I take away from this is how to work with other people to get something done.

Jex: I learned a lot from this project, about myself and how to work in a team. I started off a little slow with my steps, it was hard to figure out how to place everything. Once I got my wheels spinning, it quickly became fun experimenting with all the ways to make our project cool. One of the more challenging parts was trying to make sure every one of our steps connected and flowed. I think that is what really made this a team project, we all worked so well together and our project shows for it. I also enjoyed learning more about nuclear energy, and how the energy is used. Overall, this was an amazing project to be a part of.

Emma: Going into this project, I was very nervous. I thought that I wouldn't be able to contribute to the group and project very well because I don't know a lot about engineering and I am not the most artistic person. I quickly figured out that I don't have to be the best at those things to contribute. I ended up figuring out a step all on my own and from there I was able to contribute other step ideas and even design ideas. There were many times that the ideas I gave, or my team members gave, didn't work out which then caused some panic but with our teamwork and problem-solving skills we were all able to work together in order to complete this project. I am very proud of all of us and am so grateful I got this opportunity. It has definitely been an experience I will never forget.

Jaci: While this project was very stressful at times, it's definitely rewarding in the end. Projects like these take dedication and time, which is difficult for most of us to fit into our schedules. After all the hard work, seeing the end results is extremely satisfying. The most frustrating part of this project is when your ideas just aren't working right. I learned many different ways to deal with these scenarios, which helped me learn new problem-solving skills along the way. All in all, this project was a great learning experience and I'm very thankful I had this opportunity. **Kennedy:** This project taught me so many problem-solving skills, from solving problems individually to solving problems as a team. My biggest problem that I had to solve individually was learning how to listen to everyone's ideas and decide together what the best choice would be.

One of our biggest group problems as a group was the chemical step. We struggled to get the right mixture of baking soda and vinegar. This was a crucial step to figure out because it was our first step. In the end, I learned so many new problem-solving skills that I can use in the future.