Waunakee Community High School

Engineering Machine Design Contest 2024

Marty McFly's Mechanics

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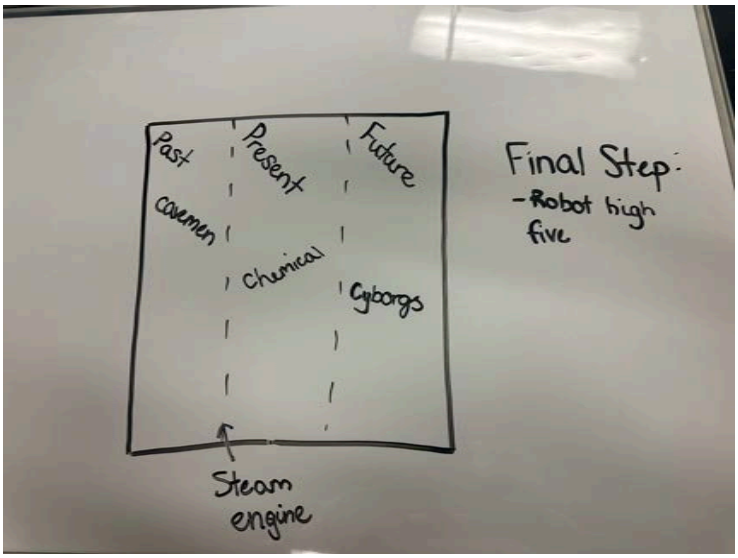
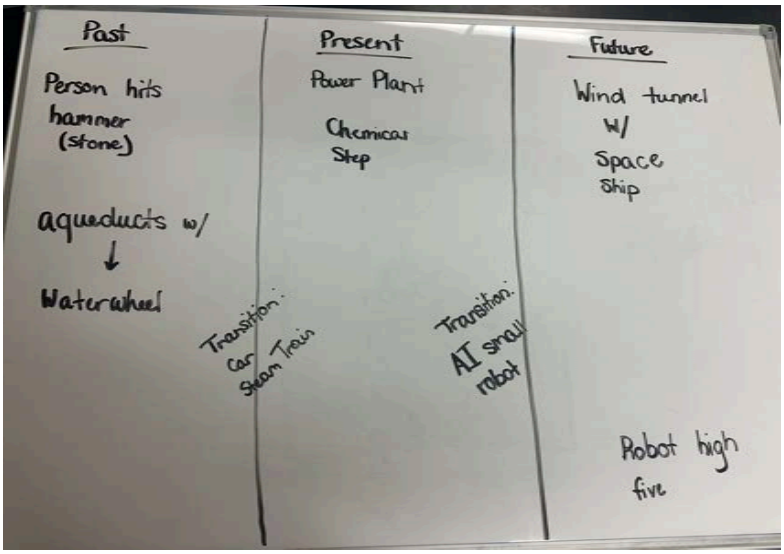
Design Sketches

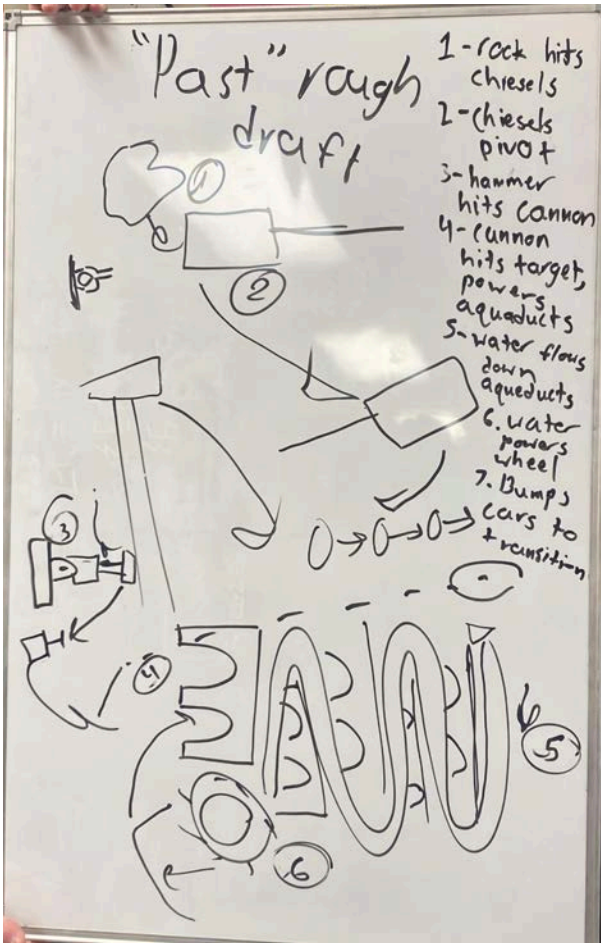
Overall Initial Design Ideas:





Our interpretation of this year's theme was to come up with a design that pinpoints major technological studies throughout centuries. We wanted to incorporate machines and technology from multiple different eras, so we divided our machine into 3 key time periods. The first section is the past. When we brainstormed the past, we thought of the ancient civilizations - the Greeks, Romans, and Egyptians - and the beginning of man - cavemen, neanderthals, and homo sapiens. For the present, we thought about the more modern eras of the late 1800s to now. We brainstormed inventions such as cars, both old and new, the steam engine, and modern-day electrical processes, primarily hydroelectricity. For the future, we have used our imaginations. Since AI and robotics have become a very pivotal part of technology, we've assumed that in the future, these elements will be more powerful and effective. Our future consists of multiple robots, cyber cities, and space themes.

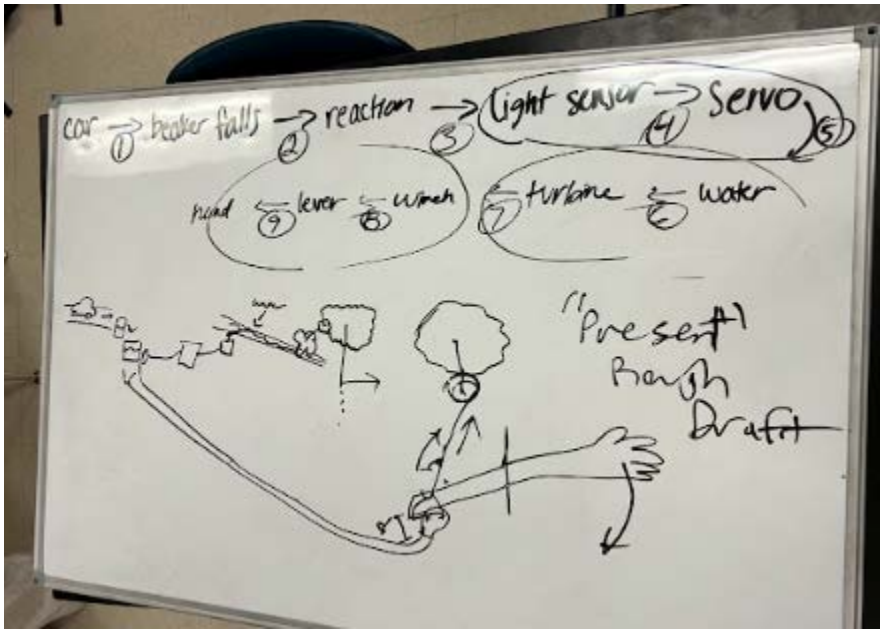
Past Initial Sketch:



The background of the past consists of a blue sky and the base is painted green and textured to look like grass. There won't be any other detail on the backdrop because the aqueducts will be standing up against the back so it will block any detail we would put in. For the past, we looked at the inventions of ancient civilizations of the world. We start with a "stone/rock hammer" to hit the chisels, which are some of the oldest tools known to man. Using a medieval cannon as a form of old warfare machinery, we wanted to trigger a makeshift aqueduct system to power the water wheel, as we wanted to represent the wheel, another early invention. The wheel will move and bump cars or a small train into a line and that will be the transition between the past and the present. We want different models of cars to represent the advancement in vehicular technology. An alternative to the cars would be a train, preferably one that looks like a steam engine to at least mention the industrial revolution because a lot of heavy machinery was invented during this time. Since Regionals, we've added one step to this section. We've extended the ramp so the domino releases a toy train and causes it to

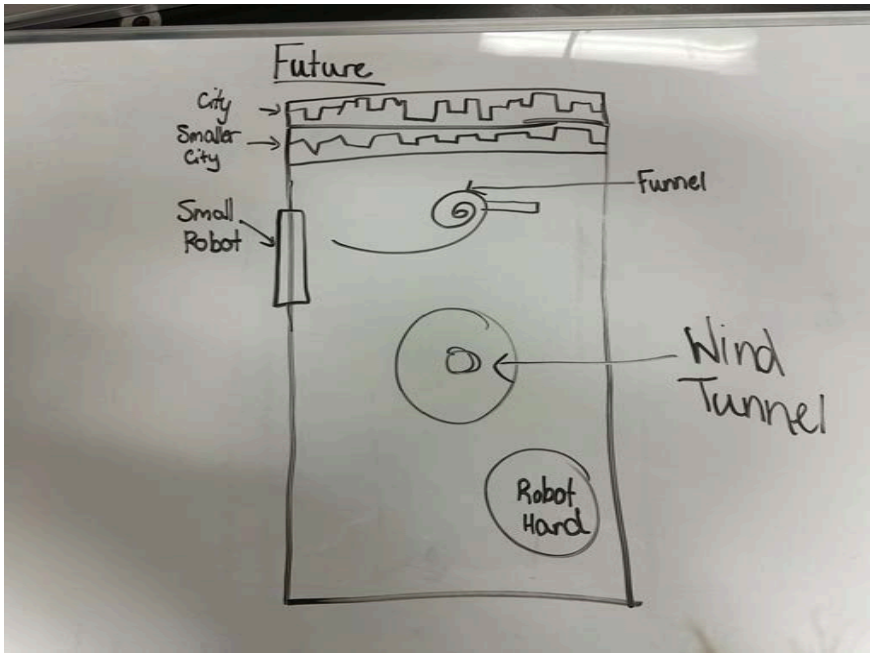
hit a Delorean we found at Walmart. The Delorean sets off the photogate. The Delorean is perfect because was have a “Back to the Future” theme so we can travel through the eras in style.

Present Initial Sketch:



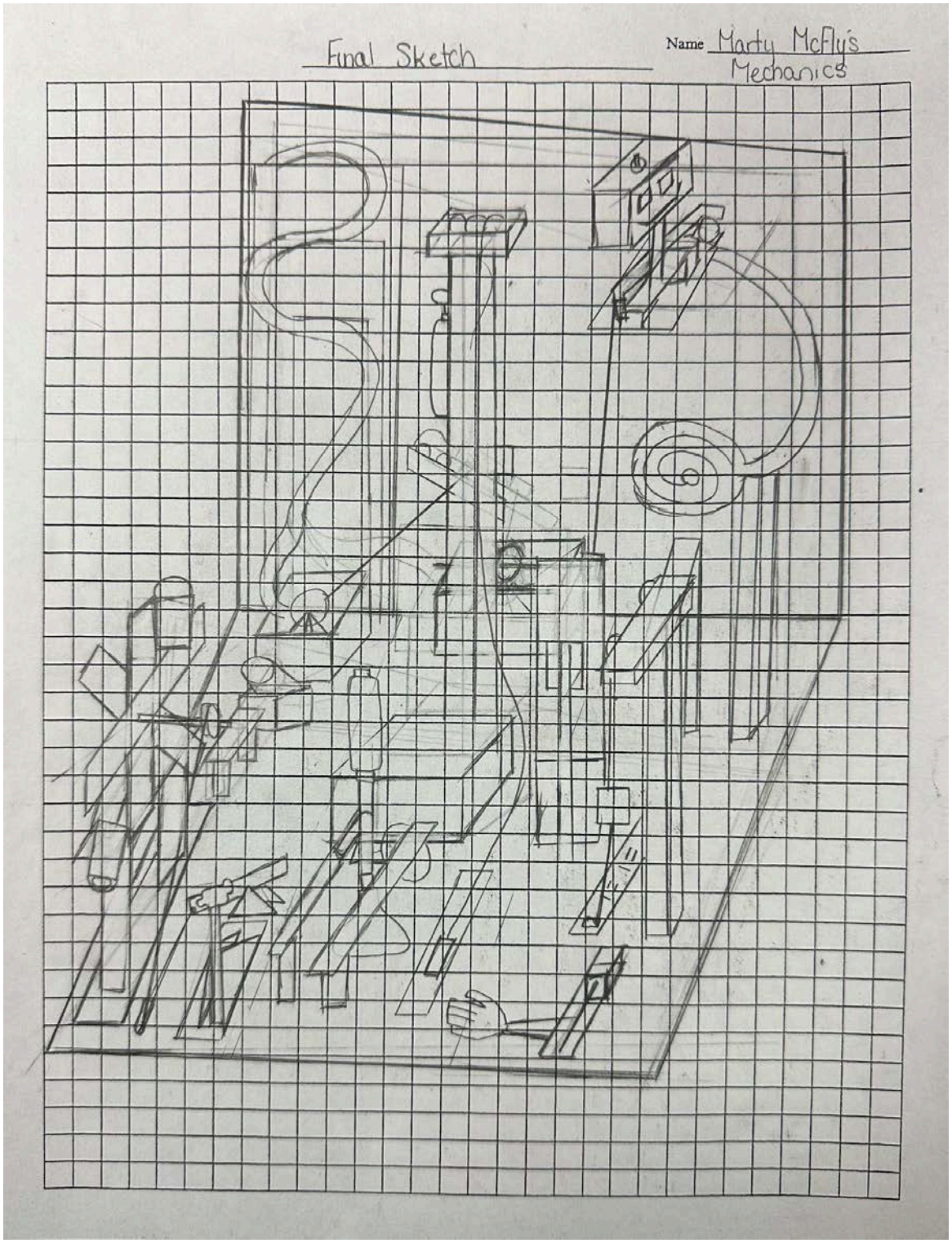
The color scheme for the present theme is gray to represent our current world with concrete and skyscrapers. The original plan for the present group was to have the car from the end of the past group hit a beaker to make chemicals spill into another beaker, to make a color change. This would be sensed by a light sensor that would make a servo motor rotate to release water down a tube. The water would make a turbine spin, this turbine would be attached to a gear system, the turbine spinning would also cause the gears to spin which would lift a pulley. The pulley would move the crude robot arm leading into the future group. The chemical reaction would be a stoplight reaction, meaning it changes colors, which represents our current times because we use stop lights every day. Also, the water and turbine are similar to a hydroelectric dam which are also frequently used in our current world.

Future Initial Sketch:



The background for the future section consists of neon colors of purple and pink on black to bring out the cyber city theme. We want to draw buildings on the back in silver pen to add to that. A small robot will be the transition from the present to the future, it is supposed to be smaller looking, almost scrawny, like a prototype because it is the beginning of what robots are compared to what they will be in the future. We have the robot knocking a ball into a funnel as if it is a hover car of some sort diving into the cyber city. It will then knock something into the wind tunnel. The wind tunnel is a makeshift alien ship takeoff using a fan. The alien spaceship will trip a sensor of some kind that operates a much more advanced robot hand that will move upwards to give a physics student a high five. Since Regionals, we've updated the high five to be between a 3D printed hand we've created, and a prop hand, as we can't have a student's hand involved for the Championship.

Final Sketch and Description



The schematic above is from Regionals. The hammer in the left corner starts off the machine, hitting a lever. The lever has a string connected to the end that moves up when the hammer hits the opposite side of the lever. The string is within a pulley system, and the lever pulls the string, causing the pulley system to turn the giant gear. The giant gear spins and drops two balls down a ramp and into a small aqueduct house. Within this house is the button to start the water pump. The pump pushes water through the pipes of our aqueduct system and it flows onto a wheel. The wheel has a string attaching it to a domino. As the wheel spins, the string is shortened and pulls the domino out from in front of the car. The car blocked by the domino is now free to roll down the ramp and past the photogate. The car sets off the photogate and this activates the motor which opens the valve on our chemical contraption.

The valve opens allowing vinegar to fall into the beaker and mix with the sodium chloride. These two chemicals mixing lightens the solution from purple to clear. The lightening of the solution is sensed by a light sensor and this sets off the motor that unscrews a bottle cap on our water tower. The bottle is pressurized and water flows onto a wheel. The wheel turns and tightens a string which is attached to the hand of our robot, Bubba.

Bubba's arm is pulled backwards by the string and hits a ball. The ball rolls down a ramp and onto a wooden marble run. It drops down onto another track and down into a pulley. The weight of the ball pushes down one cup in the pulley system and raises the other side. The other cup is connected to a piece of string where the other end is glued to a power strip "on" button. The string pulls the button up, turning on the power strip, thus turning on the fan. The fan blows an alien spaceship upwards, the air being caught by a parachute. A line follower senses the spaceship and sets off the two motors connected to the robot and human hands. The motors move each hand towards each other and meet in the middle to high five.

For the Championship we've added two more steps, one in the past and one in the future. The car behind the domino rolls down a ramp and hits a Delorean which is what rolls by the photogate to set off the chemical step. We've added another hand on a motor so both hands move into a high five, not just the robot hand.

Machine Steps and Descriptions

Past:

The backdrop is painted blue to represent the sky, and the bottom board is green to represent grass and plants.

Stone tools were some of the first man made inventions dating back to prehistoric times, the hammer is an example of an early tool.

1. Hand hits a hammer, causing the hammer to fall.
2. The hammer hits a lever which pulls a string attached to a gear.

The first gear was actually invented in China back in 2700 BCE. It was more prevalent during the industrial revolution but we wanted to acknowledge the historic routes

3. The gear spins and drops two balls onto a button which turns on the water pump.

To involve water, we wanted to create a makeshift aqueduct system from ancient Roman times.

4. The water pump moves water through the aqueduct to spin a water wheel.

This wheel is a lot less advanced than our other wheel in our machine, mainly because we want to highlight the advancements of the wheel and its multiple applications over time.

5. The water wheel pulls a domino out from where a train rolls down the ramp hits the back of a Delorean
6. The Delorean rolls down a plank and sets off the photogate with the front bumper.

Present:

The backdrop is blue to represent the sky, and the bottom board is gray to represent the city, roads, and the disappearance of greenery.

7. The photogate activates the motor connected to the vinegar bottle.
8. The motor opens a valve allowing the chemicals vinegar and sodium hydroxide
9. Another motor spins a magnet underneath the beaker, which is attracted to a magnet within the beaker, causing a stirring motion to speed up the chemical reaction. The reaction is a change in color.

Our chemical step represents the expansion of knowledge about chemicals and how our society contains our materials in this day and age.

10. The change in color sets off a light sensor
11. The light sensor opens a bottle cap on a water bottle and pressurizes the water, allowing water to flow from the bottom

Our water wheel and pressurized contraption reflects on the advancement of physics since the time of the Roman aqueducts and represents the more modern day electrical methods such as hydroelectric power.

12. The water hits a water wheel causing it to spin
13. The spinning wheel winds up string tied to the robot's arm which will spin the robot

Future:

The backdrop is black with spots of neon yellow and purple as well as specks of white to represent a futuristic city at night. The bottom board is also painted black to represent the shadows of massive buildings and the night.

14. The robot arm hits a metal ball, causing it to roll down a ramp, onto a track, and around a spiral marble run

The metal ball is spiraling downwards into our futuristic city, as if it's some sort of hover car from the future

15. The ball falls down the middle of the marble run and onto another short track where it falls into a cup connected to another cup via pulley system
16. The ball's force causes its cup to pull down, raising the other cup which is connected to a string

The cups on the pulley represent the fall in the human workforce and the rise of advanced technology taking their place someday in the future.

17. The raised cup pulls on the string, causing the end of the string attached to the switch on the extension cord to turn on the fan

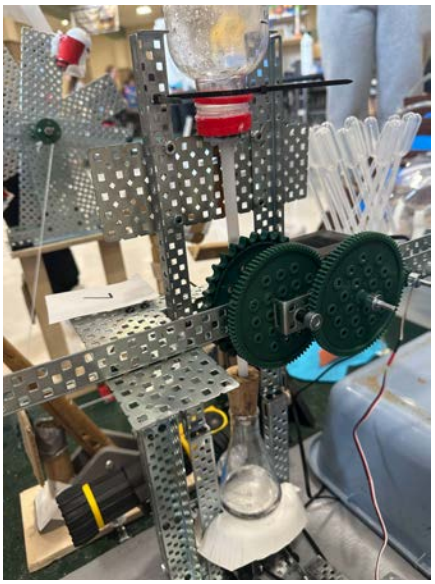
We thought a UFO looked very futuristic compared to a regular rocket ship, and we wanted an element of space travel represented in our machine especially since NASA and space exploration are becoming more prevalent topics of research.

18. The fan blows an alien spaceship upwards and the spaceship sets off a light sensor
19. The light sensor activates a first motor and a robot arm will twist upwards.
20. The light sensor activates a second motor and a human hand will twist forwards. The two hands meet in the middle and form a high five.

Our final robot hand is more advanced looking than our starting robot as to show the advancement in technology.

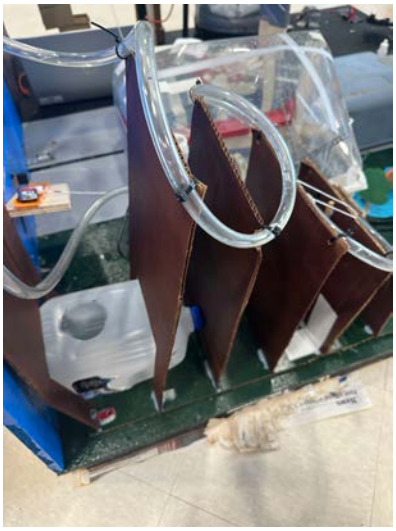
Applied Stem Processes

Chemical Component:



For our chemical reaction, our chosen chemicals are Sodium Hydroxide and Vinegar, also known as Acetic Acid. When Sodium Hydroxide and Acetic Acid react, they neutralize each other, creating Water - Hydrogen Dioxide - and Sodium Acetate. We have put a phenolphthalein indicator in with the Sodium Hydroxide, which causes it to turn a magenta color. When the Sodium Hydroxide with the phenolphthalein indicator mixes with the Acetic Acid, the color changes from magenta to clear. Our chemical step is connected to an electrical step using a light sensor. The light sensor will detect more light passing through the solution due to its color change and the sensor then activates the next step. The vinegar is kept in an upside-down water bottle blocked by a valve. The Sodium Hydroxide and phenolphthalein indicator are in a beaker below the water bottle. A motor opens the valve and gravity pushes the vinegar down into the beaker, allowing it to mix with the Sodium Hydroxide phenolphthalein indicator mixture.

Fluid Component:

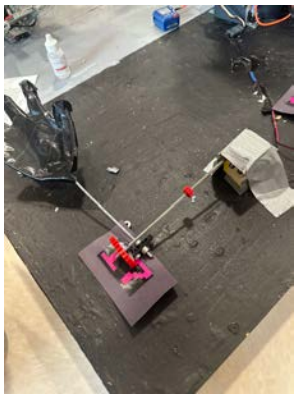


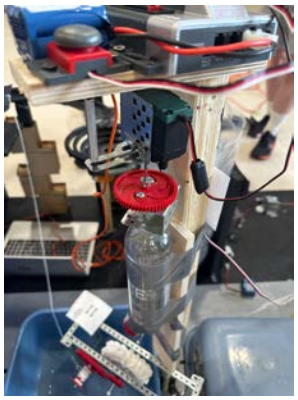
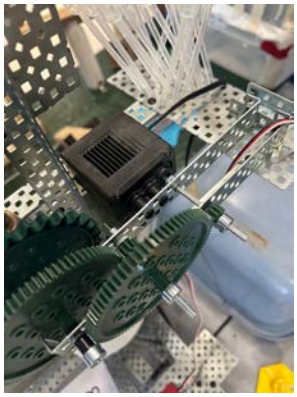
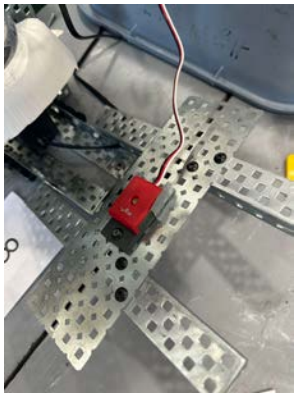
Our fluid step occurs in the first third of the machine and is set up to be our aqueduct system in the past. To fit with the aqueduct theme, we've chosen a hydraulic system that consists of water. A ball hits the button that starts the pump. Water - stored in a milk jug - is pumped through the tubing system and flows into a container. There is a less advanced wheel suspended in the container. The water that is pumped out flows onto the wheel, causing it to turn. While the wheel is a simple machine consisting of a wheel on its axle, the pumping of the water through the aqueducts is our hydraulic power.

Electrical Components:

We have multiple electrical components within the present and future, and one electrical component during the transition from the past to the present to keep up with the theme of the past and its absence of electricity.

The transition from the past to the present includes a car that moves by a photogate and the photogate activates a motor for our chemical step. In the present, we have a motor system set up to turn the valve on our chemical component step. The chemical step also includes the light sensor which is programmed to detect the change in light when the chemicals change color. We have another motor that turns to unscrew the cap of the water bottle for the water wheel, also set up in the present. In the future, we have a line follower aimed towards the inside of our wind tunnel and it will detect the alien spaceship. An electrical motor with an axle connected to it moves the robot hand to give a high five. All of these electrical components are running on separate vex cortices, one for each step, and the coding is all downloaded from our computer in the future section of the machine.



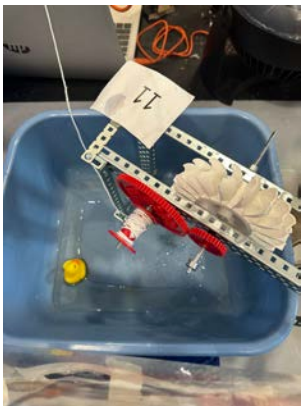






Simple Machine Components:

Almost every step in the past section is a simple machine. The chisels are on an inclined plane, allowing them to swing in the correct direction. The hammer acts as a lever, which hits a more traditional-looking lever. This regular lever pulls up some string within a pulley system that is connected to a wheel and axle. A makeshift gear is constructed on the wheel and axle so it will spin with the weight of the balls in the cups. The water wheel at the bottom of the aqueduct system is a wheel and axle, however, the axle is hidden by the cardboard structure. The ramp where the cars go down is an inclined plane. It tilts the cars and gravity pushes them down into the present.

The present is primarily made of electrical components, but the hydroelectricity step consists of a wheel and axle for the water wheel. The axle has another wheel on the outside that has a string wound around it. The string winds up as the axle turns.

The future starts with an inclined plane for a ball bearing to roll down. The ball bearing rolls down another ramp but it's much more curved but it could be considered an inclined plane. The ball is still pushed by gravity down the curved ramp. We have a pulley system that the ball bearing falls into that has a string attached to the switch on the power strip to turn on the fan.
Our final simple machine is the axle which the robot hand is attached to. It is connected to the motor which turns it upwards.

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Machine Components

Key: = Recycled

= Reused

Item	Quantity	Cost
Ball Peen Hammer	1	$12.97
Mini red solo cups	2	$1.25
Milk jug	1	$3.13
Hot wheels track	1	$16.99
3D printed lever holder	1	NA
Hot wheels car	1	$3.49
Plastic Pipe	1	$5.98
Paper Towel Tube	2	$4.79
Wooden Popsicle Stick	1	$4.99
Wooden Lever	1	NA
Roll of String	1	$7.95
Water bottle	2	NA
Vex V5 Kit Material Set	1	$4 723.95
PVC Pipe	3	$8.98
Cardboard Corner	1	$15.99
3x3 foot Cardboard Sheet	1	$15.99
Water pump and button	1	$69.99
5x5 foot cardboard sheet	1	$15.99
Large Plastic Container	2	$11.96
Plastic wheel	1	$8.99

3D Printed Water Wheel	1	NA
Glass Beaker and Cork	1	$17.99
Valve lever	1	$11.59
Pipettes	20	$1.59
Vex Cortex	3	Part of Vex Material Kit
Vex Motor	3	Part of Vex Material Kit
Lego Blocks	46	$21.42
Foam Pipe	2	$5.18
Overhead Transparency Sheet	1	$6.99
Jenga Block	2	$15.99
Laundry Detergent Cap	2	$20.98
Plastic Funnel	1	$1.99
Power strip	2	$11.97
Room Fan	1	$16.99
Computer	1	$379.99
Mini Extension Cord	3	Part of Vex Material Kit
Pulley Track	2	$8.99
Plastic Sheet	1	$18.00
Plastic Bag	1	NA
5x5 in foam block	1	$9.99
Line follower	1	Part of Vex Material Kit
Light Sensor	1	Part of Vex Material Kit
Button	1	Part of Vex Material

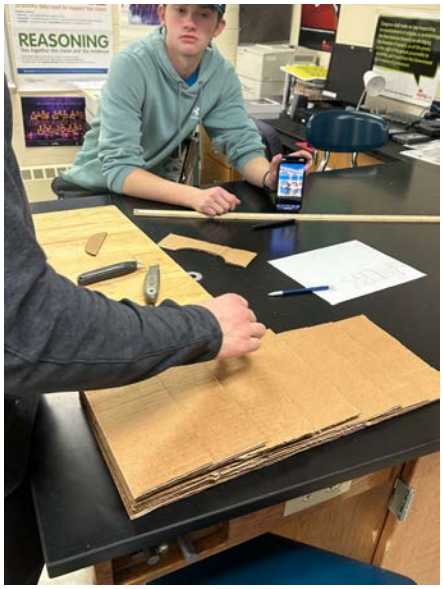
		Kit
Vex Remote	1	Part of Vex Material Kit
Aluminium Foil	1	$6.99
Wooden Hand	1	$20.00
Roll of Duct Tape	2	$5.18
1x1 in wood pillar	8	$31.92
1x3 in Wood	1	$9.99
1x4 in Wood	1	$8.59
5x9 in Wood	1	$34.50
6x12 in Wood	1	$34.50
4.5x8 in Wood	3	$103.50
1x1 in Wood cube	7	$15.99
15x2 in Wood	1	$34.50
2.5x2 ft Wood Backboards	2	$37.98
2.5x5 ft Wood	2	$37.98
Gallon of Water	2	$1.29
Wooden Marble Track	1	$17.99
Hot Glue Gun	1	$9.97
Photogate	1	Part of Vex Material Kit
Various colors of paint	6	$101.94
Delorian Car	1	$5.99
Flex Tape Roll	1	$21.20

Our machine is 17.5% recyclable and or recycled materials, 38% reusable materials that we will then put back for our physics classes to use in the future, and 44.5% other materials that were provided by our physics classrooms that are considered teaching

hardware. The cost of all the materials is $5 985.05, however we did not pay this much for our machine. Some of our teammates were super generous to bring in items like the room fans. We had three to choose from, but chose Gideon's black fan because it had the correct power for what we were trying to do. We were able to borrow an old water pump from one of our teammates' friends for free as well. These were by far our greatest finds that we could save money on. We were trusted with our school's Vex kits as well and we made sure to take care of the parts we used because of how expensive they are to replace. With the majority of our supplies being provided, the amount of money we actually spent on our machine was $47.19.

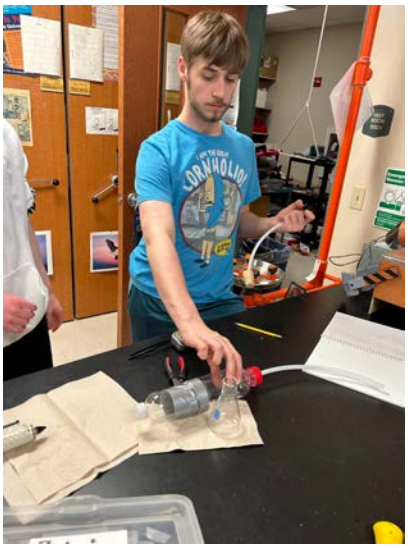
Building Process

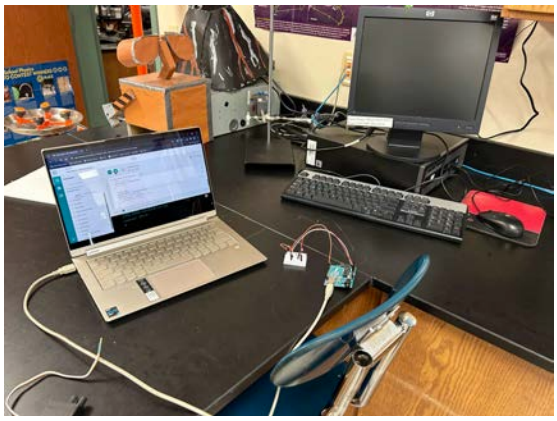
Past:

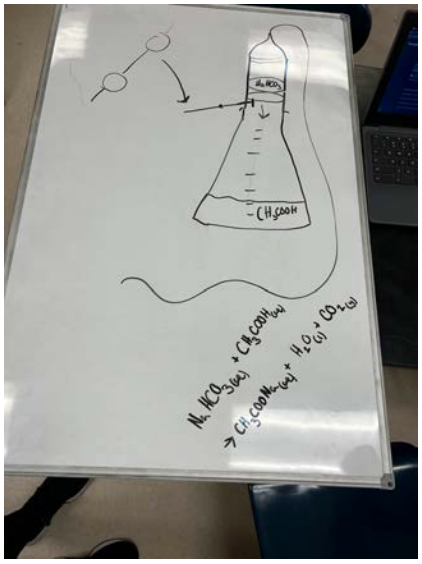


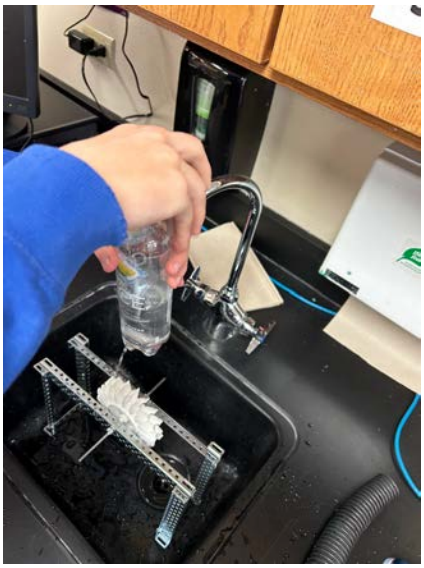

CLAIM
EVIDENCE
REASONING

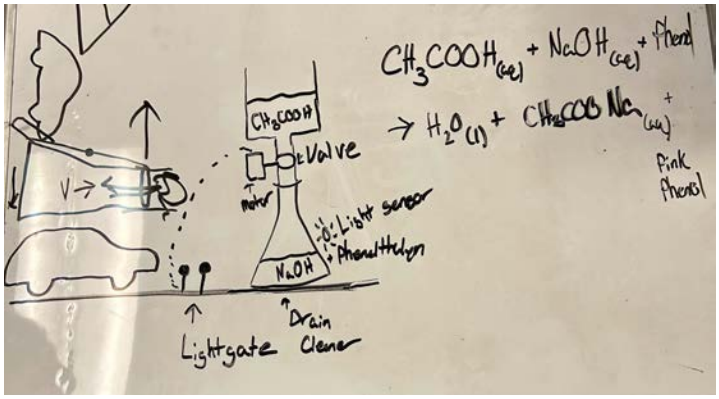
Present:

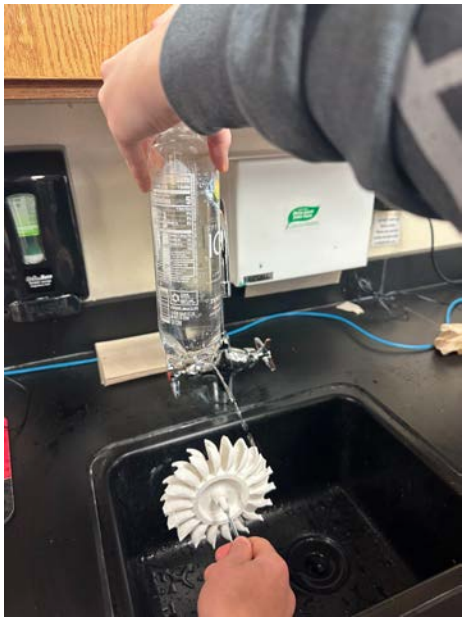


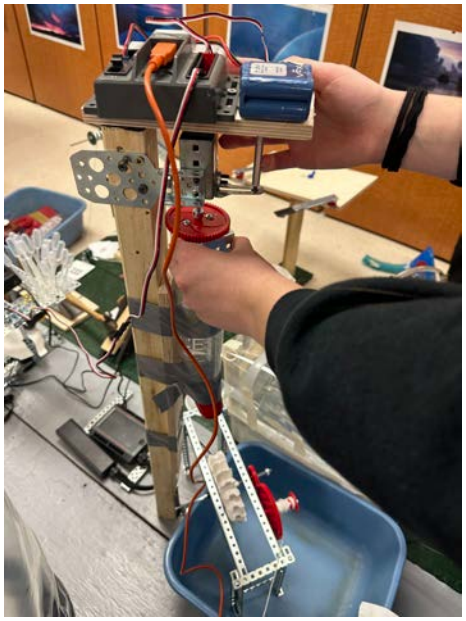



CH_3COOH
$NaHCO_{3(aq)} + CH_3COOH_{(aq)}$
$\rightarrow CH_3COONa_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

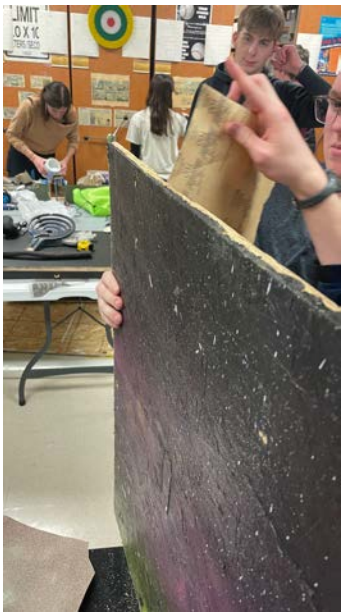


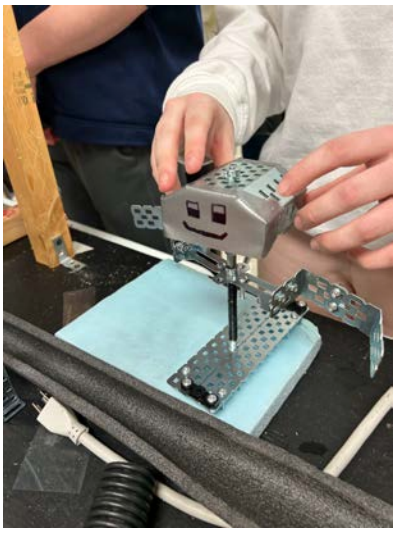

$CH_3COOH_{(aq)} + NaOH_{(aq)} + Phenol$
$\rightarrow H_2O_{(l)} + CH_3COONa_{(aq)} +$
Pink Phenol
CH_3COOH
Valve
Meter
Light sensor
Phenolthalein
$NaOH$
Lightgate
Drain Cleaner

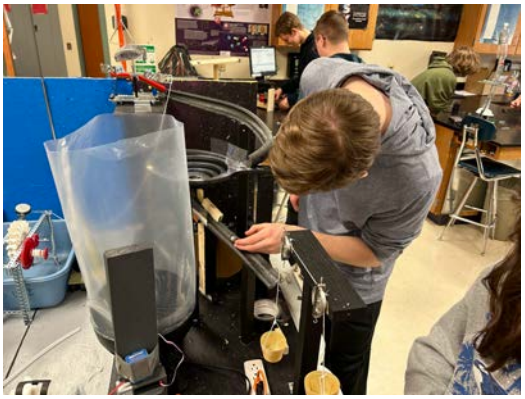


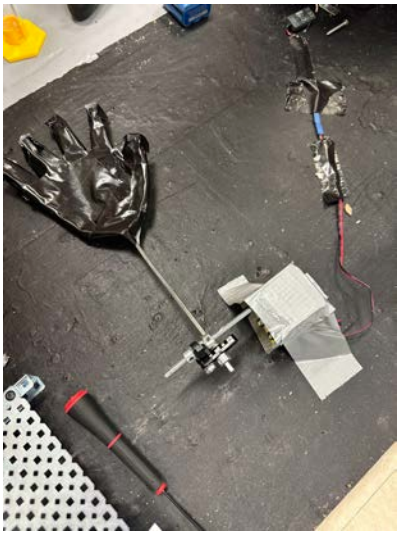


Future:

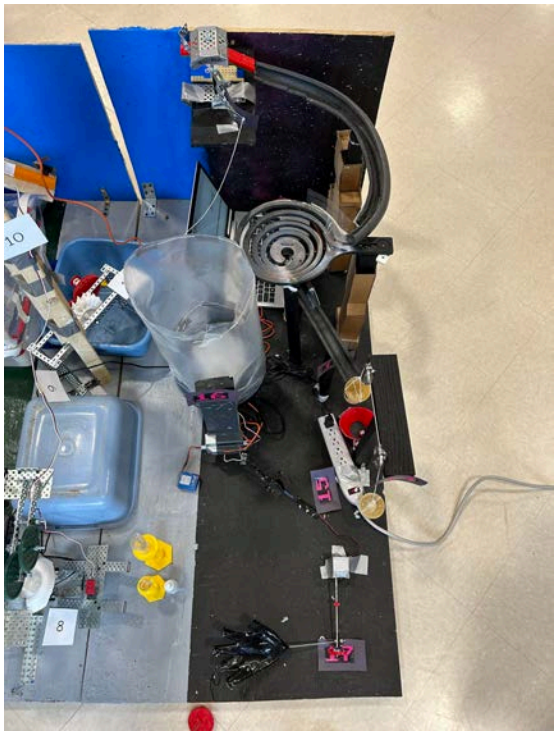


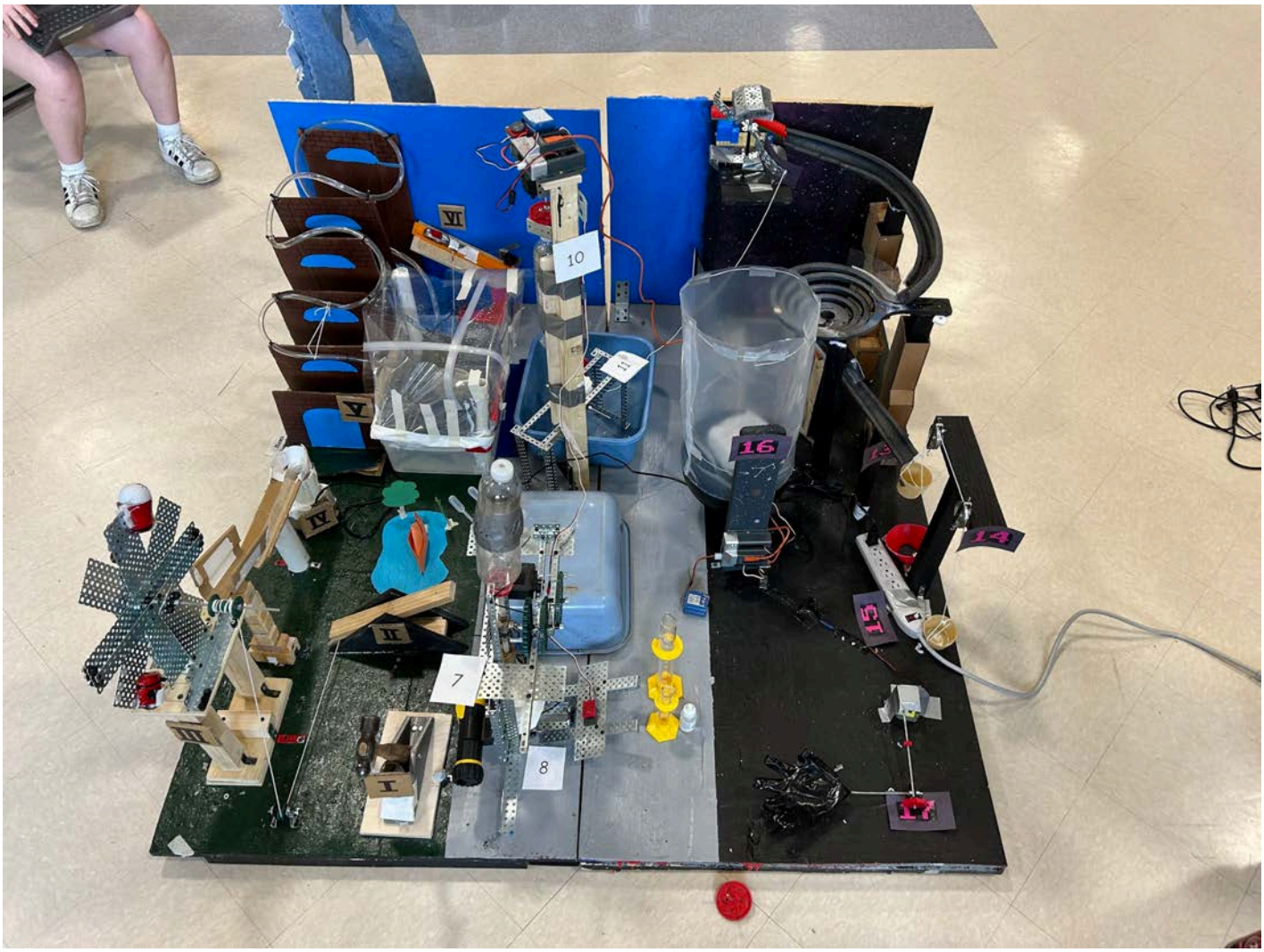






Final Machine

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Reflection

At first, we didn't exactly know what human to technology transfer meant, but that left the concept up to our imagination. Our interpretation of the topic was to showcase the advancement of technology over the centuries. Our final goal of the machine was to produce a high five from a robot hand to one of the teammates. We wanted the end result to be a literal human to tech transfer and what's more literal than a high five between a robot and a human?

To make the process less overwhelming and to progress the theme of our machine, we divided our big team into three smaller teams, one for each section of the machine. This was also helpful because we only had 18 classes to put our machine together so we were able to divide and conquer. Each group had to narrow down to 5 or 6 steps. With so many high achieving teammates, we all had to work on our communication skills and sharing our ideas in a way that wasn't to say our own ideas were better than others.

Being split into 3 sections also meant we had to communicate effectively between the past, present and future groups so our steps would connect correctly. One of our most complicated steps is the chemical tower, and it's actually a part of the transition from the past to the future. The photogate is what sets off the motor for the tower, so there was a lot of coding and communication between the teammates in charge of the chemical process and the teammates working on the past so everything worked as it should.

We made adjustments to a few steps. Originally, we had a "domino effect" chisel system start the machine. We replaced it with the hammer because the chisels would breach the machine borders and they didn't have enough force to actually hit the hammer. We ran into issues with the axle for the water wheel too. We switched a wooden axle to a metal axle and the machine worked much better. The container for the water wheel leaked, so we solved this issue by creating an enclosure around the waterwheel and pump. We also created many renditions of our UFO so that it would fly to the height we needed. Using light weight foam and cardboard, we shaped it, then tested out multiple plastics to use for the parachute. A regular plastic bag worked best.

The whole construction process was very enjoyable and all group members participated immensely. We all learned how important and valuable it is to listen to others' suggestions even if at first one doesn't necessarily agree. We also learned that the most simple systems can be the best option and work more efficiently than elaborate creations.

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