The Flat Earthers
Waunakee High School

Team Members

Kaleb Ament
Kai Bennett
Rowan Burton
TJ Doescher
Zach Hurlebus
Ryan Khalili
Ethan Neville
Fritz Simon
Danny Zimm

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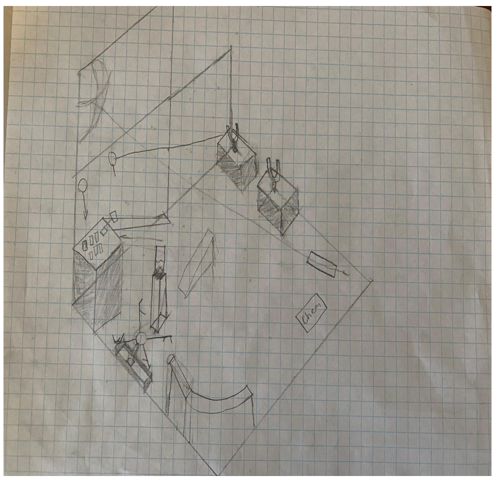
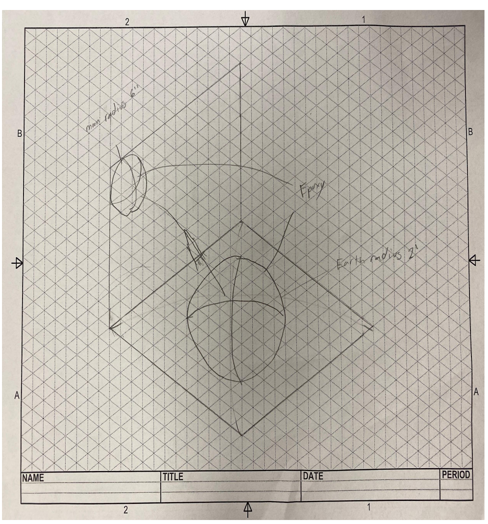
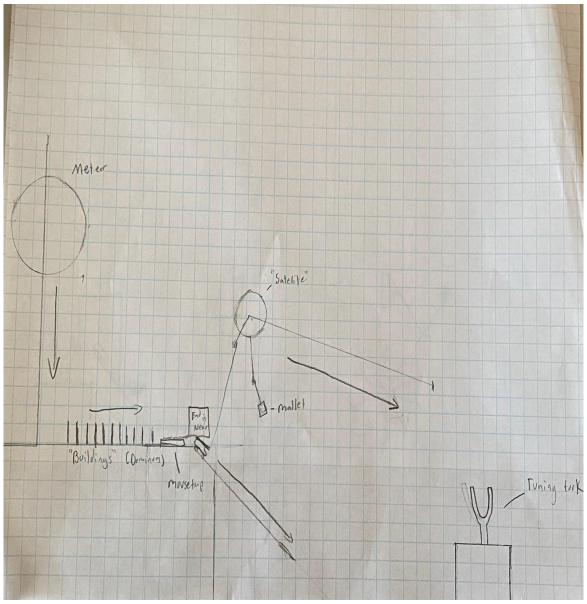
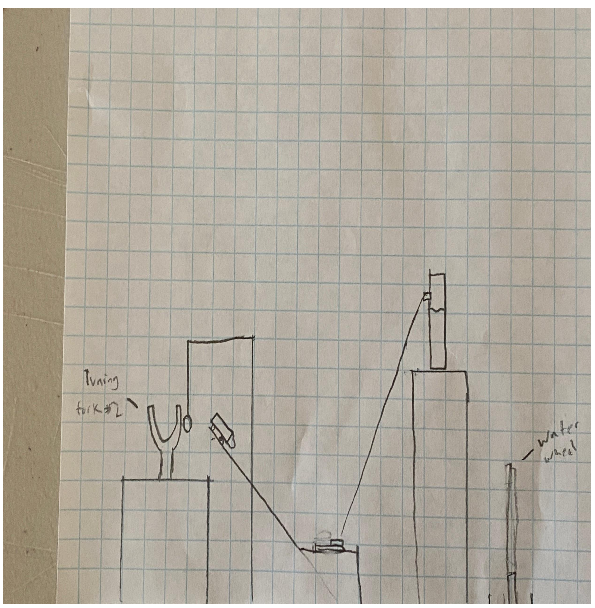
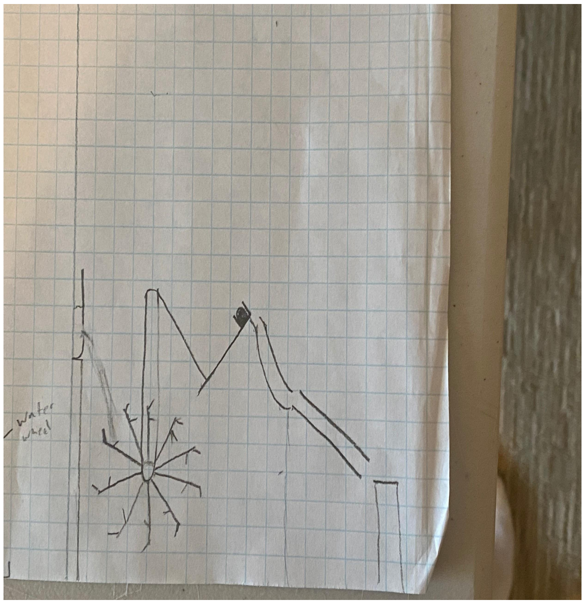
Initial Sketches and Descriptions

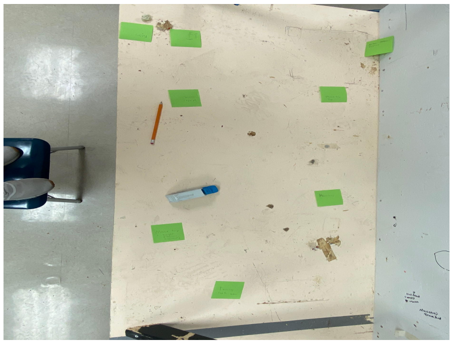
 	Early on in our process we knew we wanted the goal to be to land on the moon. From there we started thinking about various steps to lead to that. Initially, we had ideas for steps but not everything connected together so we had to think of ways to connect what we had. At one point we had an idea to build everything on a sphere which was the earth but we soon realized that wouldn't be possible in the time we had. Due to this, we settled on a flat platform, hence the name "Flat Earthers."

	This is an initial sketch of the first steps of the machine. These steps remained largely the same except for the satellite step. Initially, we were going to have the car pull the satellite but we decided it would be best to have a string that pulls a pin rather than just the car and satellite connections.
	The steps between the tuning fork and the container of water changed significantly from our initial design. At first, we were going to have the ball hit a toy truck triggering a mouse trap and pulling a cork. All of this got changed because the ball couldn't push a toy truck, and we realized the pneumatic volcano would fit better in the space. This is an example of how we used the engineering design process because through testing we adapted the solution to our problem.

	The section between the water wheel and releasing the ball stayed pretty similar to our initial idea. We had to test the length of the string to get the pulley to lift the lever enough. At first, we were just going to have a ball on a track, but Ms. Rademacher showed us the magnetic tube she had and we thought that would be a good step to create a delay.

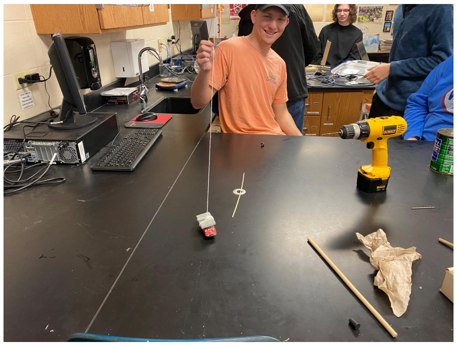
<u>**Progress Photos**</u>

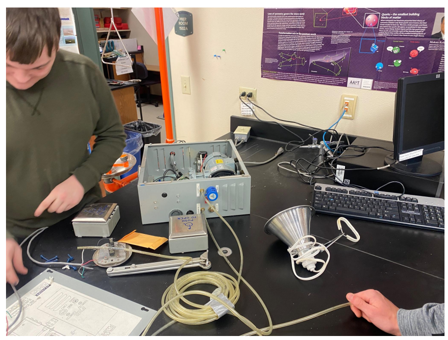
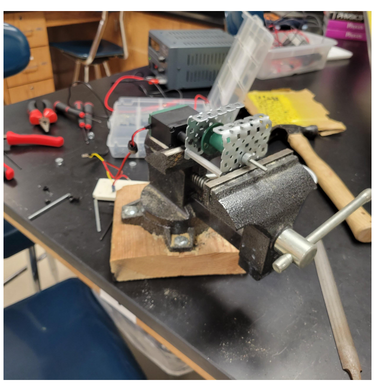
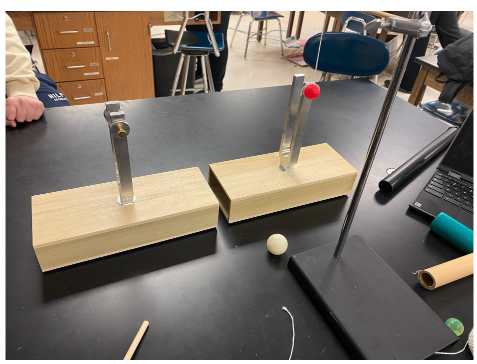
Days 1-2



Day one was spent brainstorming ideas and generating concepts. We came up with several ideas and eventually ended up with the theme of escaping earth because of a meteor shower. On day two we started constructing the base and finalizing ideas for the steps we wanted to do. Once we had ideas for steps we used sticky notes to map out roughly where we wanted each step to go. This allowed us to plan sufficient space.

Days 3-7

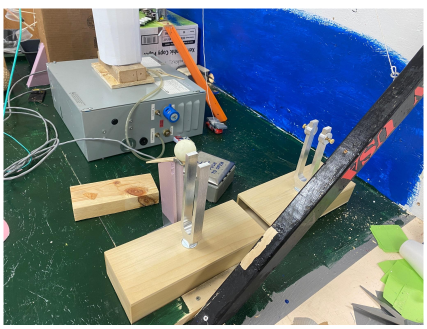


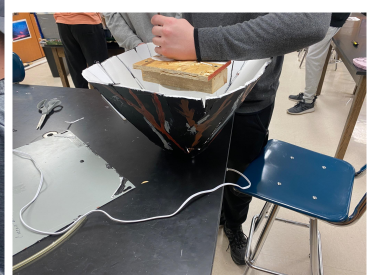





For the next several days of our design process we broke off into smaller teams with each group focusing on five to six steps. Most of the steps started with construction and testing on the lab tables. This allowed us to focus on many different steps at once because we weren’t all trying to work on the board.

Days 8-13



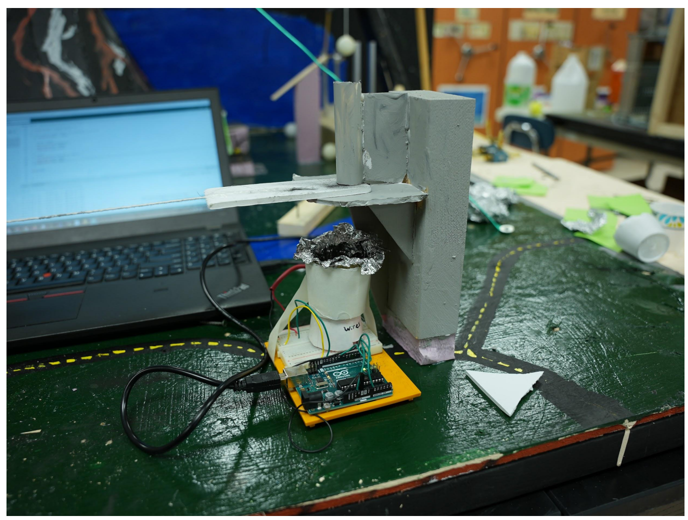




Once we got to about the halfway point of the project progress started happening very quickly. After testing steps on the lab tables we started to transfer them to the board and connect them. During this time there was a lot of testing of a few steps at a time, figuring out the connection, and in some cases, we found adding another step was the easiest way to bridge what the different groups had made.

Days 14-16

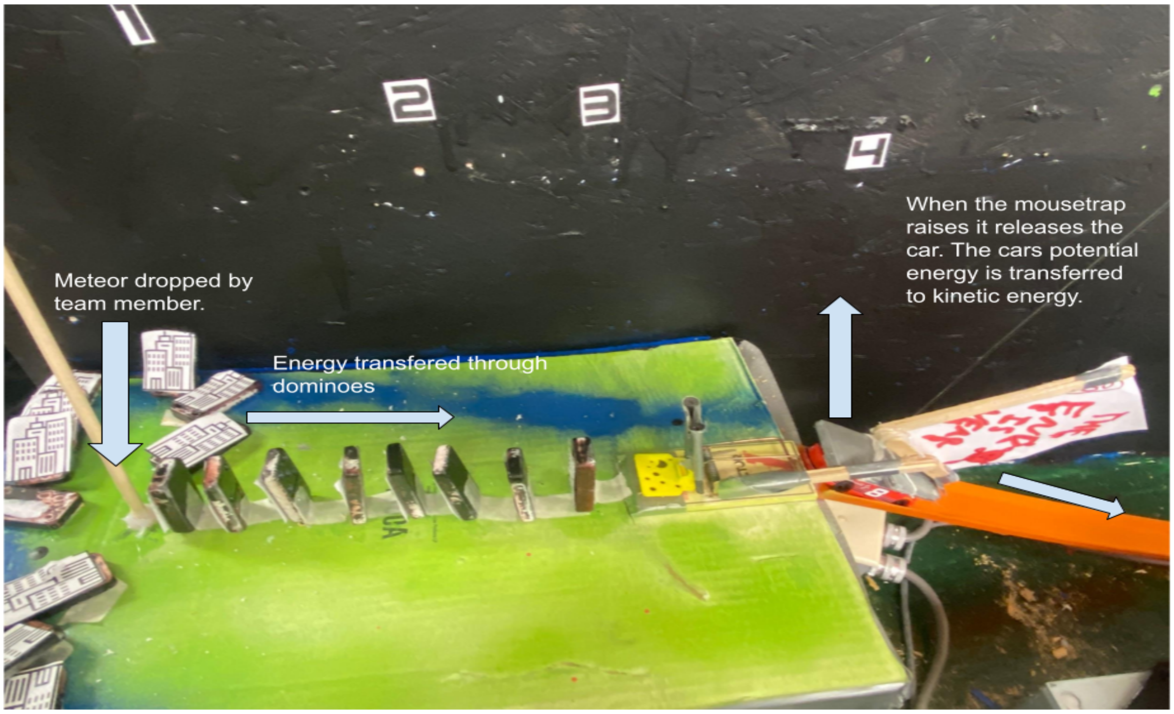
Once we had constructed our first full prototype we had to test it many times to figure out issues that could be improved. While testing we ran into a lot of problems that needed to be solved. We realized that our satellite didn’t consistently hit the tuning fork and needed to be adjusted so we added a mousetrap to hit it. We also added a tube instead of a ramp to guide the ping-pong ball. Another thing that happened during this time was our chemical step overflowed which ruined the sensor and breadboard. We had to adjust by using a beaker which was more secure. After much testing and adjusting we ended up with our final machine.

Final Machine Image/Description

Overview and Theme

Our machine starts with a meteor making impact on Earth leveling an entire city of dominoes. Chaos ensues and the apocalypse is inbound. “The end is near '' flag raises which allows a car transporting precious materials to go down a ramp. This car triggers a pin and a satellite slides down the wire, crashing toward Earth. The satellite sends a signal using the sympathetic resonance of the tuning forks. Just when you think it can’t get worse, the impact causes a volcanic eruption. A pneumatic system is used to create the eruption which pulls a cork allowing water to flow. Much of the power supply is out so the people turn to the backup power generated by a water wheel. The few things that can come on the ship are transported down the ramp. Once it falls from the ramp a platform is pulled out allowing the rocket to fuel up. Finally, the ship launches, landing on the moon and raising a flag to stake our claim.

Individual steps labeled

<table>
<tr><td>Steps 1-4</td><td>
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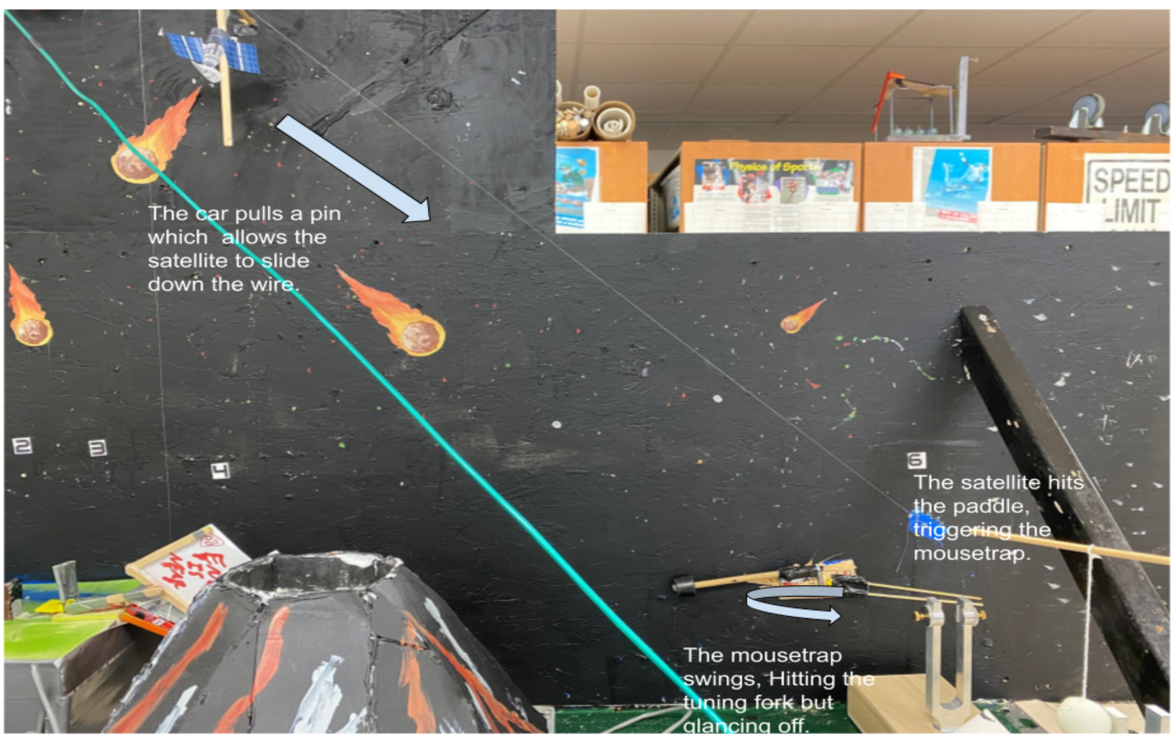
<tr><td>Steps 5-6</td><td>
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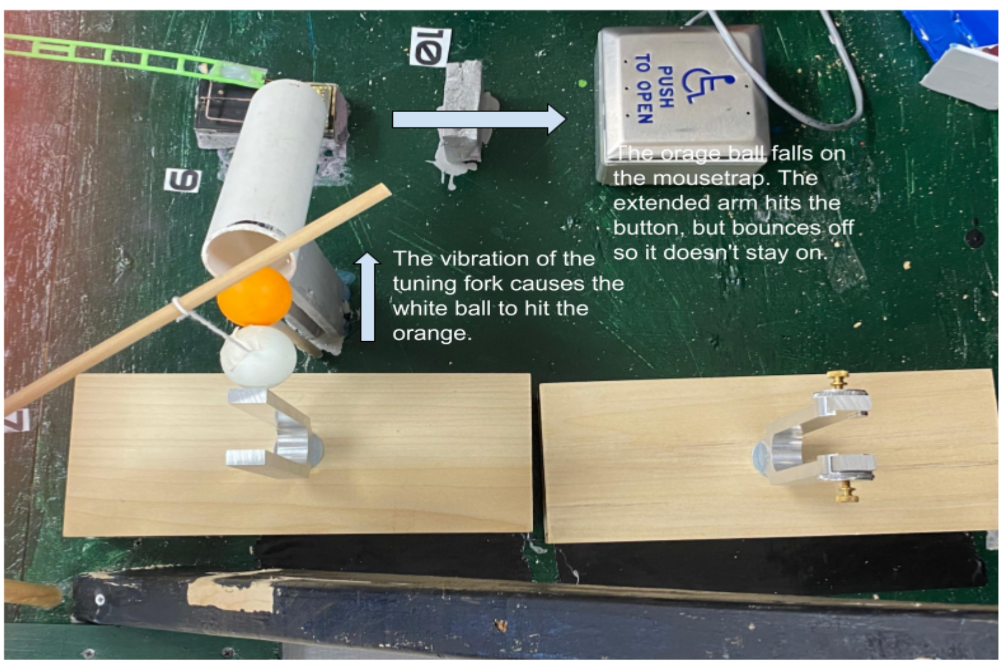
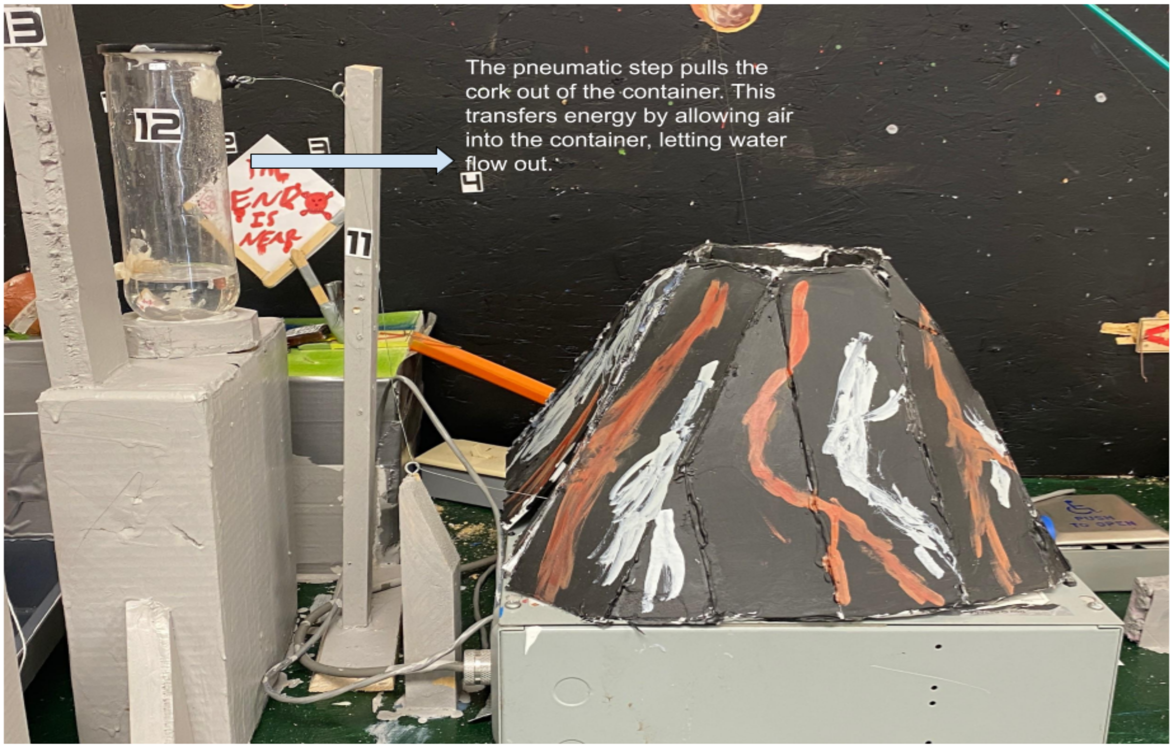
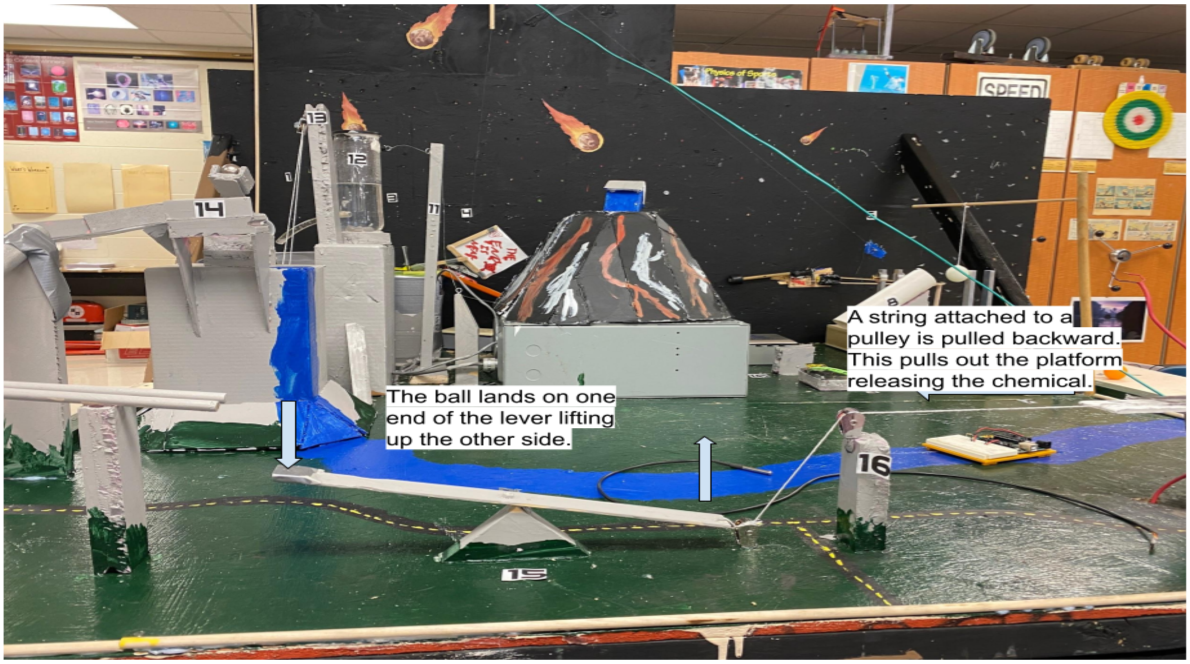
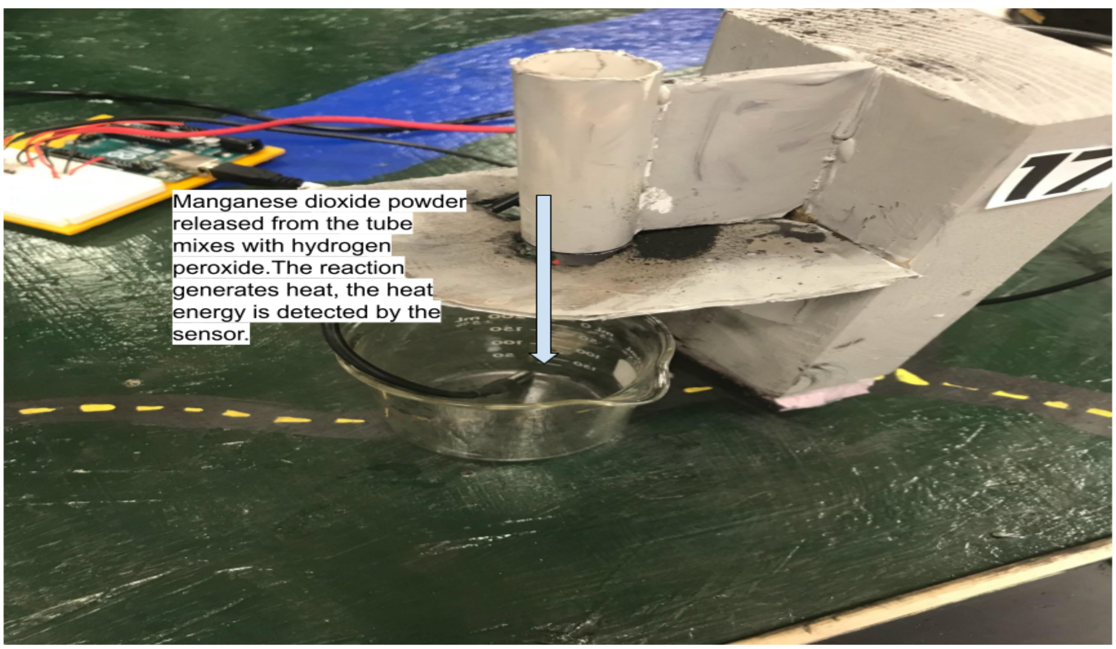
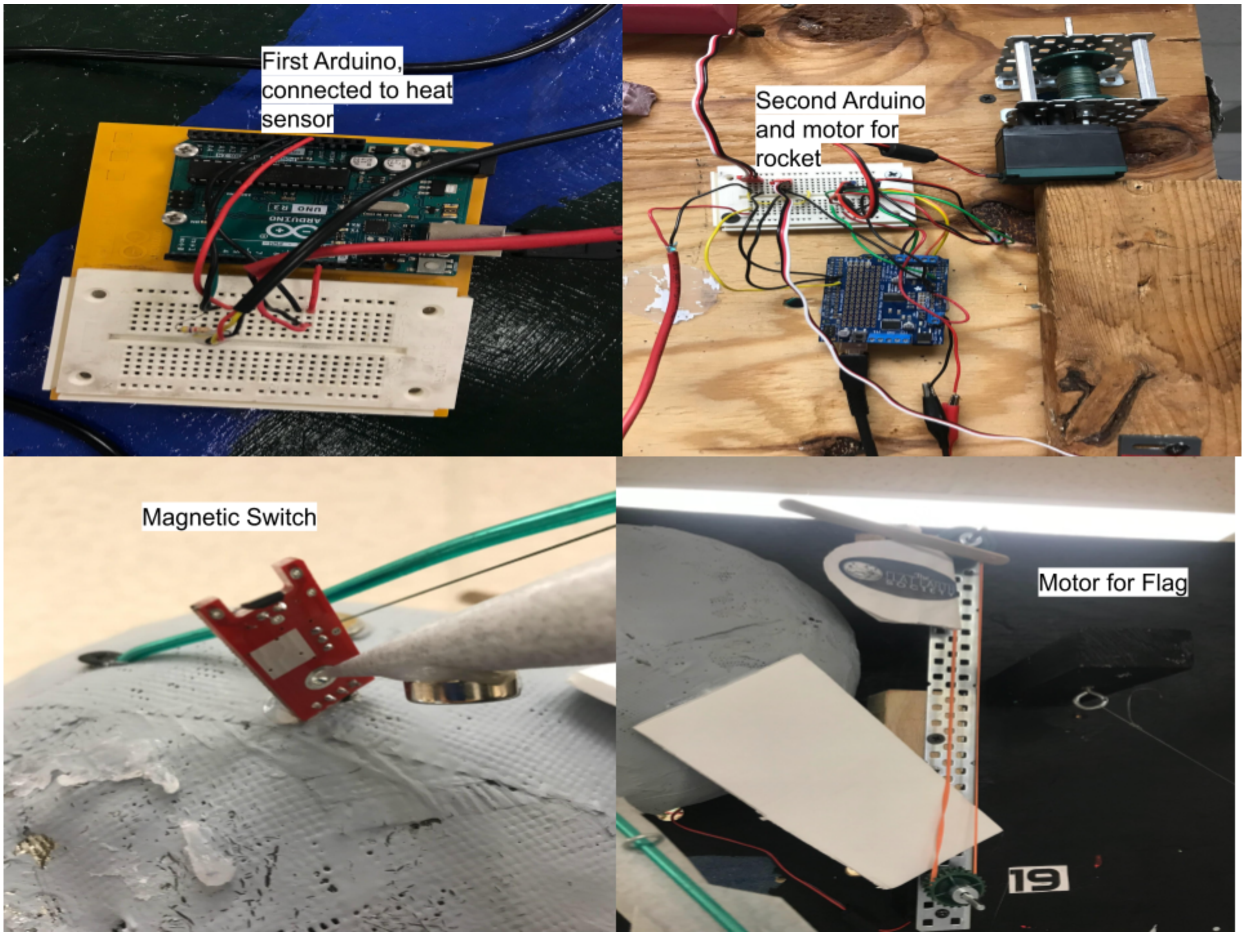
Step 7	
Steps 8-10	

Steps 11-12	
Step 13-14	

Steps 15-16	
Step 17	

Steps 18-19	

List of Machine Steps

1. Team member drops meteor (wiffle ball) onto city (dominoes)
2. Falling dominoes trigger mousetrap raising “The end is near” flag
3. Flag raising releases car down the ramp
4. Car pulls pin releasing the satellite
5. Satellite slides down wire hitting mousetrap
6. Mousetrap swings hitting the tuning fork
7. The resonance of the first tuning fork causes the second tuning fork to vibrate
8. Vibration moves the ping pong ball on the string which hits the ping pong ball on the ramp
9. The ball on ramp rolls down the tube and lands on mousetrap
10. Mousetrap hits the handicap button which starts the volcano (Pneumatic door opener)
11. Volcano launches due to the compressed air, the fishing string attached to the platform pulls cork (Advanced Step: Fluid Power)
12. Water flows out of the tennis ball container causing the water wheel to spin
13. The water wheel spins and triggers the pulley (Advanced Step: Mechanical)
14. Pulley raises the lever releasing the ball which rolls down the ramp and through the magnetic tube
15. The ball lands on a lever, the magnetic ball is attracted to the magnet on one end of the lever causing it to flip up
16. Lever pulls a string attached to the pulley, It pulls back the foam platform opening up the hole for the manganese dioxide powder to fall into the hydrogen peroxide.
17. Hydrogen peroxide reacts with manganese dioxide, and the exothermic reaction triggers the heat sensor (Advanced Step: Chemical)
18. Heat sensor initiates timer and causes the motor to start, launching the rocket (Advanced Step: Electrical)
19. When the rocket gets near the magnetic switch on the moon it triggers the motor which raises the flag. (Advanced Step: Electrical)

Applied STEM Processes

Chemical

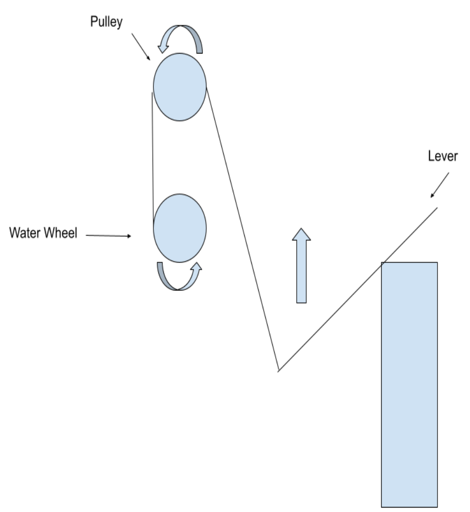
For the chemical step, we had initially planned on starting a chemical reaction that would trigger the next step. We figured that a reaction between two household products would be best considering it would be safe. We ended up choosing to react hydrogen peroxide with manganese dioxide; the chemical reaction between hydrogen peroxide and manganese dioxide is a catalyzed reaction for the decomposition of hydrogen peroxide into water and oxygen gas. This reaction occurs naturally without a catalyst, due to the single weak oxygen bond within hydrogen peroxide, called a peroxide bond. Its weakly bonded nature makes the decomposition of hydrogen peroxide thermodynamically favorable, which essentially just means that it will naturally occur over time. The manganese dioxide acts as a catalyst, which lowers the activation energy of the reaction, allowing it to occur instantaneously. The decomposition of hydrogen peroxide is exothermic, meaning that it releases energy in the form of heat when ongoing. Therefore when we use the catalyst, a lot of heat is released at once. We use 33 ml of 3% hydrogen peroxide solution, which increases the temperature of the solution by about 9 degrees, more than enough for the heat sensor to be triggered.

$2H_2O_2(l)+MnO_2(s) \rightarrow 2O_2(g)+2H_2O(l)+MnO_2(s)+\text{Heat Energy}$

Mechanical

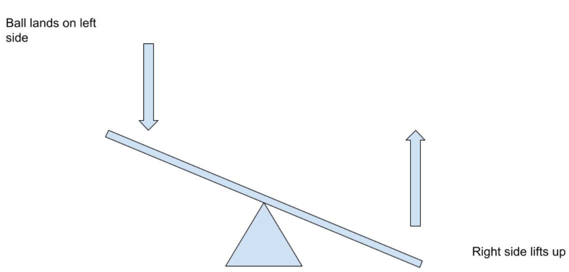
Pulley

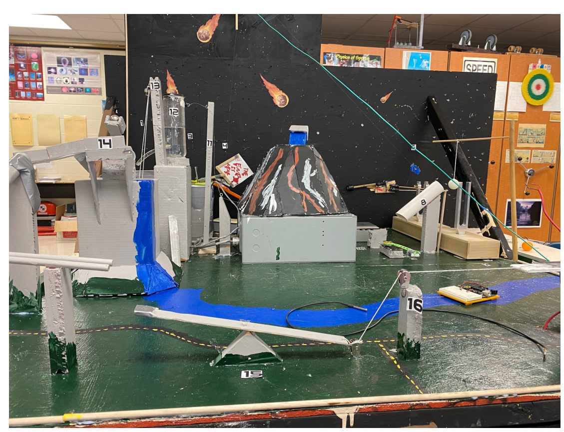
One of our advanced mechanical steps was a pulley connected to a water wheel. The pulley we used had two wheels which means we have an ideal mechanical advantage of 2. In other words, half the force is needed to lift the lever. The force to turn the water wheel and eventually lift the lever is generated from the water which spins the water wheel. To make sure we had enough water we tested to find the correct amount to fill each time.



Lever

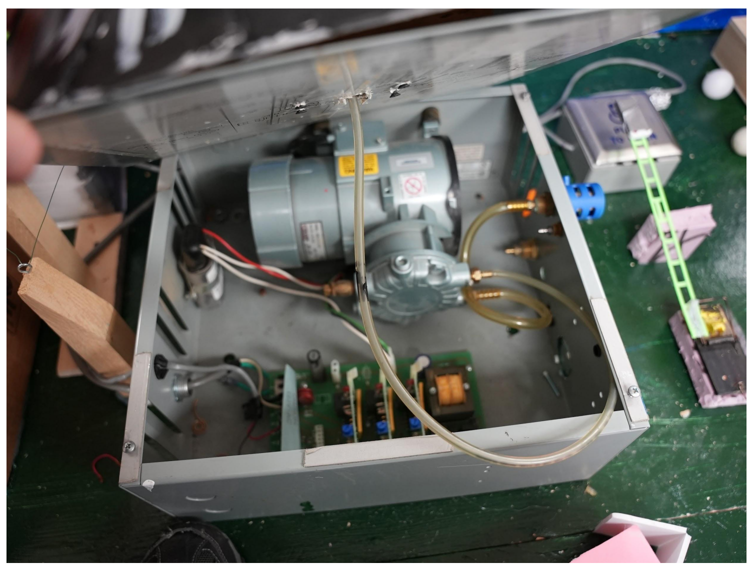
Another mechanical step we had was a first-class lever. This is a first-class lever because the fulcrum is in the middle. When the ball lands on one side it flips the other side up. The force pulls a string tight which releases the platform.





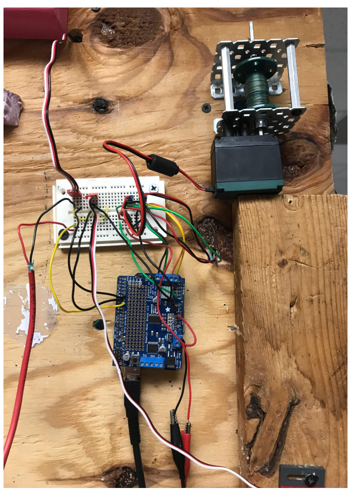
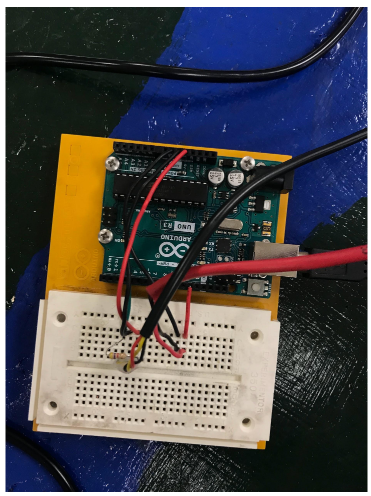
Fluid Power

When deciding what to do for our fluid power step we were originally unsure what to do. After we did some research into pneumatic systems we realized that we could use the handicap door activator that our teacher had in her classroom. Normally, the door opener uses compressed air to open a door. For our purposes, we had to modify this mechanism. To do this we took out any components that would restrict the airflow and made it so the compressor no longer held air and would only start when the button was pushed. The tubing connected to the air compressor goes into a syringe, a few seconds after the button is hit, enough pressure builds up to pop the syringe out creating the effect of the volcanic eruption.

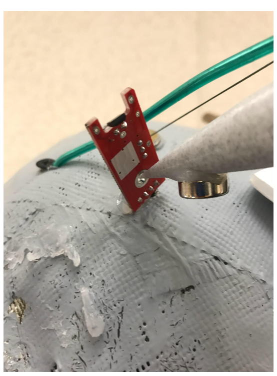
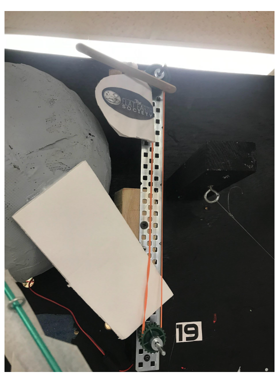


Electrical

An Arduino sends a signal when the temperature read on a heat sensor crosses over a threshold. This signal is read by another Arduino that is near the moon. The Arduino near the moon is constantly checking to see if it has received that signal, when it receives the signal it checks to see if the magnetic sensor has been triggered. If the magnetic sensor has been triggered, the motor to move the rocket up is stopped and the motor for the flag is started. It then checks if the flag has reached the top and triggered the switch, if this switch is triggered the motor stops. If the magnetic sensor is not triggered, then the motor is set to move forward. If the signal hasn't been sent from the original Arduino, the Arduino near the moon constantly checks if the reverse switch has been pressed. When this switch is pressed the rocket is lowered back to Earth. This allows us to reset the step in a quick manner. One of the biggest challenges with this step was coding it, but through a lot of trial and error, we were able to make it successful. Below is all the code and wiring.

Motor for rocket launch. Arduino connected to heat sensor.

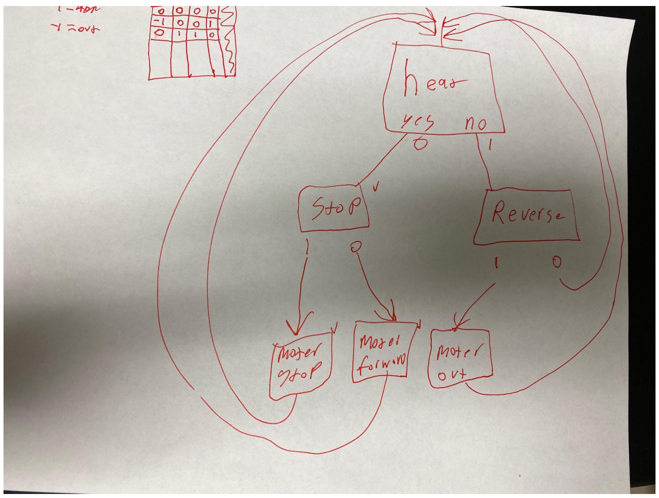



Magnetic switch and motor for the flag

Motor Code	Heat Sensor Code
#include <Adafruit_MotorShield.h> Adafruit_MotorShield AFMS = Adafruit_MotorShield(); Adafruit_DCMotor *myMotor3 = AFMS.getMotor(3);	#include <OneWire.h> #include <DallasTemperature.h> #define ONE_WIRE_BUS 4 OneWire oneWire(ONE_WIRE_BUS);

<pre>Adafruit_DCMotor *myMotor4 = AFMS.getMotor(4);
 	
const int analogInPin = A0;
int sensorValue = 0;
void setup() {
 	
  pinMode(5, INPUT_PULLUP);
  pinMode(6, INPUT_PULLUP);
  pinMode(7, INPUT_PULLUP);
  Serial.begin(9600);
 	
  if (!AFMS.begin()) {
    while (1);
  }
}
 	
void loop() {
  sensorValue = analogRead(A0);
  Serial.println(sensorValue);
 	
 int Reverse = digitalRead(6);
 int Flag = digitalRead(5);
 int Heat = digitalRead(7);
  Serial.println(Heat);
Serial.println(Flag);
if (Heat == LOW) {
  if (sensorValue >= 530) {
    if (Reverse == LOW) {
    myMotor4->run(FORWARD);
    myMotor4->setSpeed(200);
    Serial.println("REVERSE");
  }else{
    myMotor4->run(RELEASE);
  if (Flag == LOW) {
    myMotor3->run(RELEASE);
  }else{
    myMotor3->run(BACKWARD);
    myMotor3->setSpeed(200);
  }
    }
  }else{
    myMotor4->run(BACKWARD);
    myMotor4->setSpeed(200);
  }
}else{
  myMotor3->run(RELEASE);
  if (Reverse == LOW) {</pre>
	<pre>DallasTemperature sensors(&oneWire);
	
	void setup(void)
	{
	  Serial.begin(9600);
	    sensors.begin();
	    pinMode(12, OUTPUT);
	    pinMode(13, OUTPUT);
	}
	
	void loop(void){
	  sensors.requestTemperatures();
	  Serial.print(" - Fahrenheit temperature: ");
	  Serial.print(sensors.getTempFByIndex(0));
	  delay(100);
	
	  if(sensors.getTempFByIndex(0) >= 80){
	    digitalWrite(12, LOW);
	    digitalWrite(13, HIGH);
	    Serial.println(" - Launch Status: Launcing
	");
	  } else{
	    digitalWrite(12, HIGH);
	    digitalWrite(13, LOW);
	        Serial.println(" - Launch Status:
	Wating for heat ");
	
	  }
	}</pre>

```
    myMotor4->run(FORWARD);
    myMotor4->setSpeed(200);
    Serial.println("REVERSE");
  }else{
    myMotor4->run(RELEASE);
  }
}
}
```



Early plan for the code.

Cost of Machine and Percent Recycled

Wiffle Ball	Recycled	2
Wooden dowel	Recycled	5
Dominoes	Recycled	24
Mousetrap	Recycled	3
Flag	Recycled	1
Toy car	Recycled	1
Hot wheels ramp	Recycled	1
Wooden Block	Recycled	3
Pulley	Recycled	4
Fishing line	Recycled	1
Tuning Forks	Recycled	2
Ping pong balls	Recycled	2
Handicap door mechanism	Recycled	1
Tennis ball container	Recycled	1
Box	Recycled	3
Popsicle sticks	Donated ($5)	12
Plastic cups	Recycled	10
Magnetic Tube,	Recycled	1
Arduino	Recycled	2
Heat sensor	$11.58	1

Manganese dioxide	Recycled (From Chem)	1 bottle
Hydrogen peroxide	Recycled (From Chem)	1 container
Rocket	Donated ($8) (estimated from 3-D filament costs)	1
Timer	$10.18	1
Guidewire	Recycled	1
Moon (epoxy)	Recycled	1
Winch	Recycled	1
Power source	Recycled	1
USB cable	$1.47	1
Magnetic Switch	Recycled	1
Motor	Recycled	2
Foam structure	$8.00	2 sheets
Baseboards	Recycled	4
Screws	Recycled	50-60
Hinges	Recycled	1
Paint	Recycled (From previous projects)	4 cans

88.75% recycled machine	$50.23 total cost

Design Process

Define a Problem

The problem we had was to create a complex machine to complete a task following the competition guidelines and theme. From this, we decided that we wanted our task to be landing on the moon.

Generate Concepts

The first and second days of the project were spent mostly brainstorming our steps. We approached this by having a discussion with the large group and just bouncing ideas around. Once we had the general concept of what we wanted to do we split into three smaller teams that worked on and fine-tuned their assigned steps.

Develop a Solution

Once we had all our ideas we made final sketches and started the process of building.

Construct a Prototype

We broke off into three different groups. Each group was responsible for 5-6 steps. We started by testing steps on the lab tables to make sure they work conceptually. Once we got them to work on the lab tables, we brought them to the main board and started trying to put everything together and link the different groups' steps.

Evaluate and Improve

Initially we had many steps that needed to be adjusted once they got put on the board. We improved these steps through a lot of adjustments and testing. One of our main problems was the transition between the different group’s steps and adding pieces to make those transitions work.

Reflection

Successes and Challenges

Challenge: Step 4
The satellite step was one of our more challenging steps. The step went through about 4 different versions to settle on a final design. The first challenge we encountered was the satellite hitting the back wall as it slid down. To help with this we pushed out the whole wire. After that, we struggled to get the satellite to consistently hit and resonate the tuning forks. We tried different methods of the satellite hitting directly, but eventually settled on adding a mousetrap that hits the tuning fork boxes. We found this method to be the most consistent. This step was a great example of how we had to adapt from our original ideas through the process of testing and retesting until we got something that worked.

Challenge: Step 17
The chemical reaction step was another challenge for us. Early on we came up with the idea of some kind of reaction that would generate heat, but we didn't exactly know how. Our first idea was to use heat packs, but we realized that this wouldn't work fast enough and was not sustainable since they are single-use. The chemical reaction team decided it would be best to find a different exothermic reaction so they talked to one of our chemistry teachers who guided them to a safe exothermic reaction. From there we tested to find the best ways to contain

the reaction and have it heat up fast enough. The process of the chemical step taught us the importance of research and interviewing people far more experienced than us.

Success: Creative Steps
One of the things we thought was a big success was the creativity of our steps. We were able to use unique steps such as the tuning forks, the pneumatic volcano, and the exothermic reaction. One of our goals was to incorporate some unique steps and we feel we executed that well with our machine.

Individual Reflections

Danny	Before this project, I was never very good at working in groups. This was a challenge for me at the start of our machine. Over time I realized that working together is needed in a project like this, and it makes the design process much easier.
Ethan	This project has taught me just how many iterations you need to perfect a step. I worked on the chemical step and we went through many different ideas for how to effectively funnel the chemicals into a cup. I also worked on a step that we ended up not using. Ryan and I tried to make an electromagnet train that utilizes magnets and a copper coil. Though we worked hard trying to get it to work with many different attempts, in the end, we had to scrap it because it just wouldn’t work.
TJ	During This project I learned a lot about how to work with a team. One of my hobbies is building things, especially working with electricity. I really enjoyed how this project allowed me to use my skills to contribute to the whole machine. I liked being able to use my computer skills since I want to go into information technology.
Kaleb	This project taught me the importance of patience, and trying to think about how something might work in many different ways. As some of our steps went through many versions before the final.
Zach	This project has taught me a lot about adapting and compromising. Initially, we had some grand plans of building the entire system on a sphere which was a really cool idea. But we knew that based on the time we had and the steps we had to accomplish it wasn’t logical so we needed to move on from that awesome idea.
Rowan	This project gave me a lot of experience working in a large group. When we first started this project, we were all just throwing ideas out there in an attempt to get a general idea of what we wanted to do. Once we had started to divide up tasks, things began moving quickly. The constant

	communication between our group members really helped us to pull this off. This allowed for very unique ideas to emerge and for problems we encountered to be solved in a timely fashion.
Fritz	This project tested my patience almost every day. There was always something broken or not working right that needed to be redesigned. When something needed to be changed it was very helpful to have a team full of ideas to solve the problem. Even though our finished machine might run smoothly, that is definitely not how it started, although no one on the team gave up hope and I believe that was a reason for our success. Having a positive outlook on each situation kept us headed in the right direction in an efficient manner.
Ryan	With all of the challenges and struggles we faced along the way, I learned that there is always some struggle and iteration that goes into any progress. Ethan and I worked on the chemical step and a few others in its surrounding. We went through many different chemicals before we settled upon the exothermic catalyzed reaction of the decomposition of H_2O_2 with Manganese Dioxide. To come to a decision, we ended up having to do a lot of research along the way, which definitely helped expand our general chemistry knowledge. We also initially tried to make a magnetic ball go through a copper wire coil acting as an electromagnet, to launch the ball out of it into something, however, sadly after many tries and attempts, we weren't able to get that step to work and had to improvise a different combination of steps. After some struggle and hard work, we were able to develop a great chain of steps that work in synchrony with each other, to put on a great presentation.
Kai	Throughout this process I learned that the engineering design process requires lots of testing and adapting. One of the main steps I worked on was the tuning forks and ping pong ball. I had to use many iterations, testing the spacing between the forks, and the height of the string. I learned to change my thinking and not always go with the first solution. Another thing I learned was how to use everyone's strengths to work together as a team.

Reflection Word Count: 989

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