NEW BERLIN
EISENHOWER
GOLD

<u>Team Members:</u>

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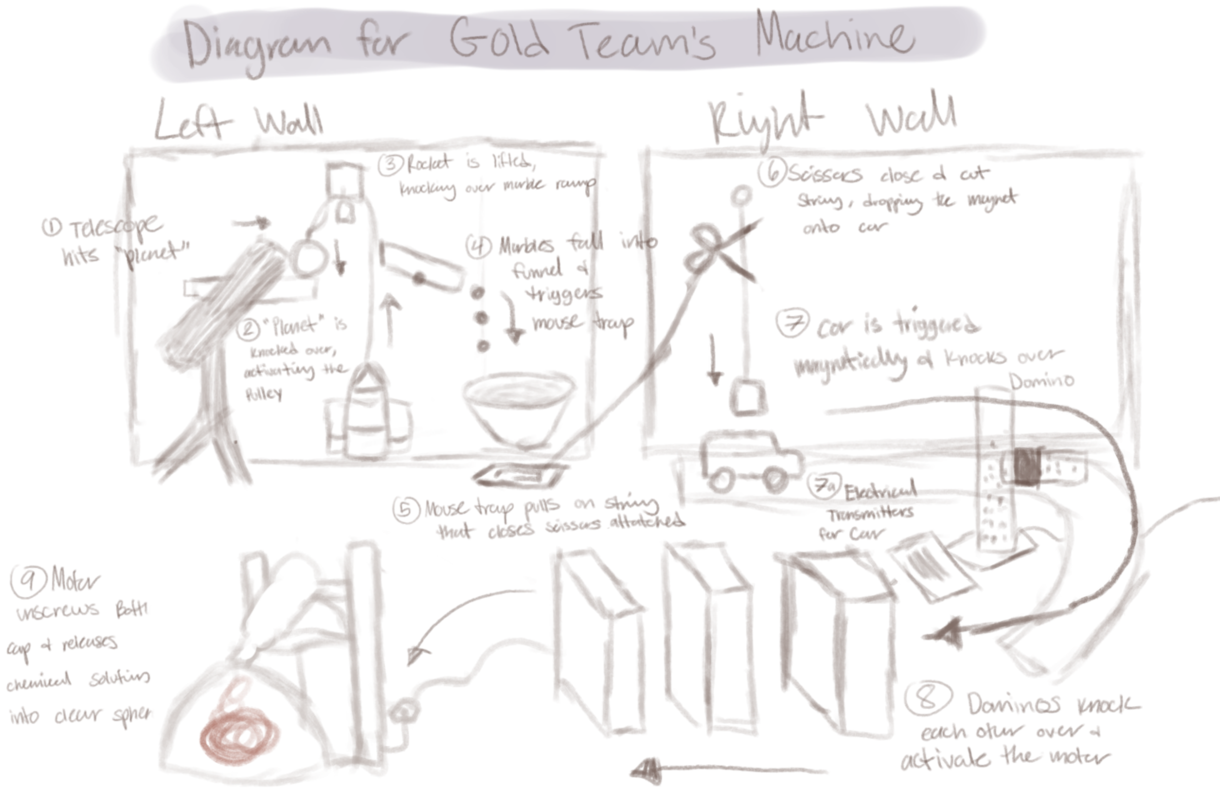
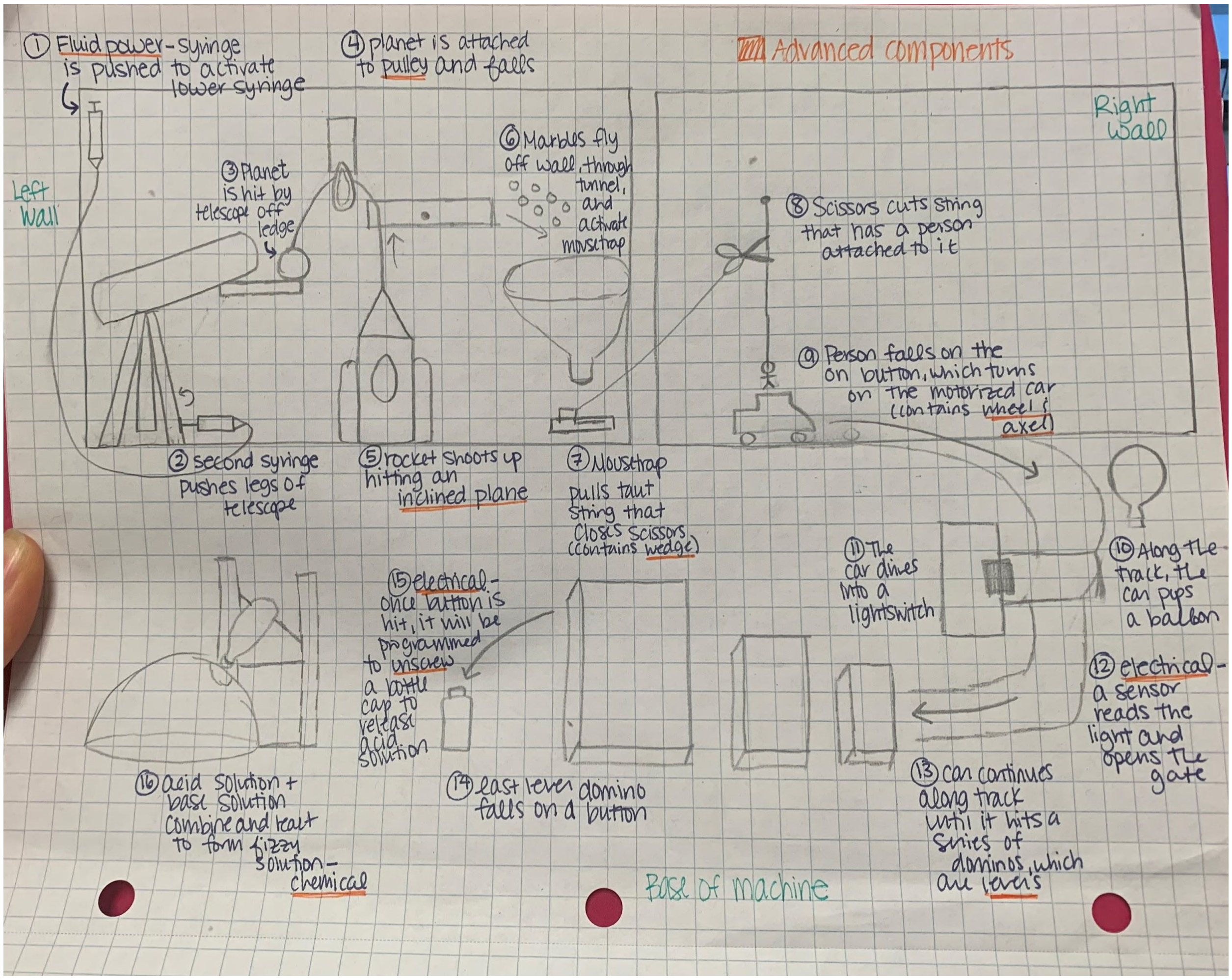
Planned Machine Design Sketch and Description





Description of Theme Understanding and Goals:

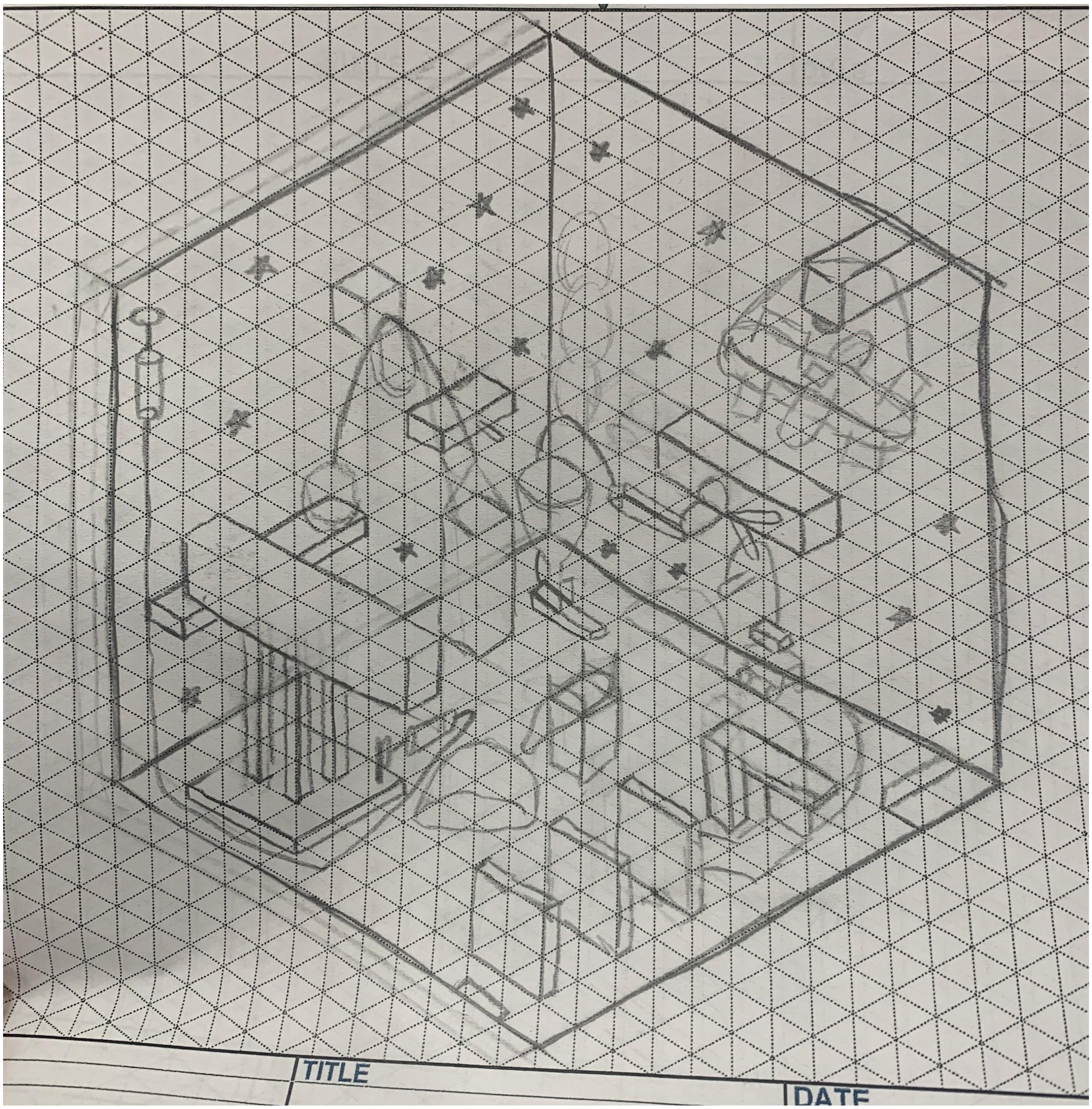
We started our brainstorming period by generating ideas for how we wanted to portray the theme "transforming space technology." Very quickly, we settled on showing how space technology has transformed through the different eras, starting with the first major breakthrough in 1610 when Galileo used his telescope to discover Jupiter's moons. We wanted to focus on past accomplishments and show how they have contributed to more recent and future breakthroughs. In essence, we decided to create a timeline throughout our machine and portray it as a time machine.

Once we established our theme, one of our goals was to accurately represent space technology through different eras, in order to ultimately show possible technological advancements in the future such as with our representation of people going to Mars.

Final (or Near Final) Machine Design Drawing/Image and Description

Machine Storyline Description:

After we were set on our theme, we picked the major events and accomplishments of space technology that we wanted to focus on and drew up an initial design for steps to represent these. Our final design ended up looking quite different because we had to add in a few connecting steps to reach the requirements for the machine and had to redesign a few steps because they weren't reliable. In relation to the theme, we created a timeline throughout, which is represented by the yellow signs, showing the major breakthroughs in space technology.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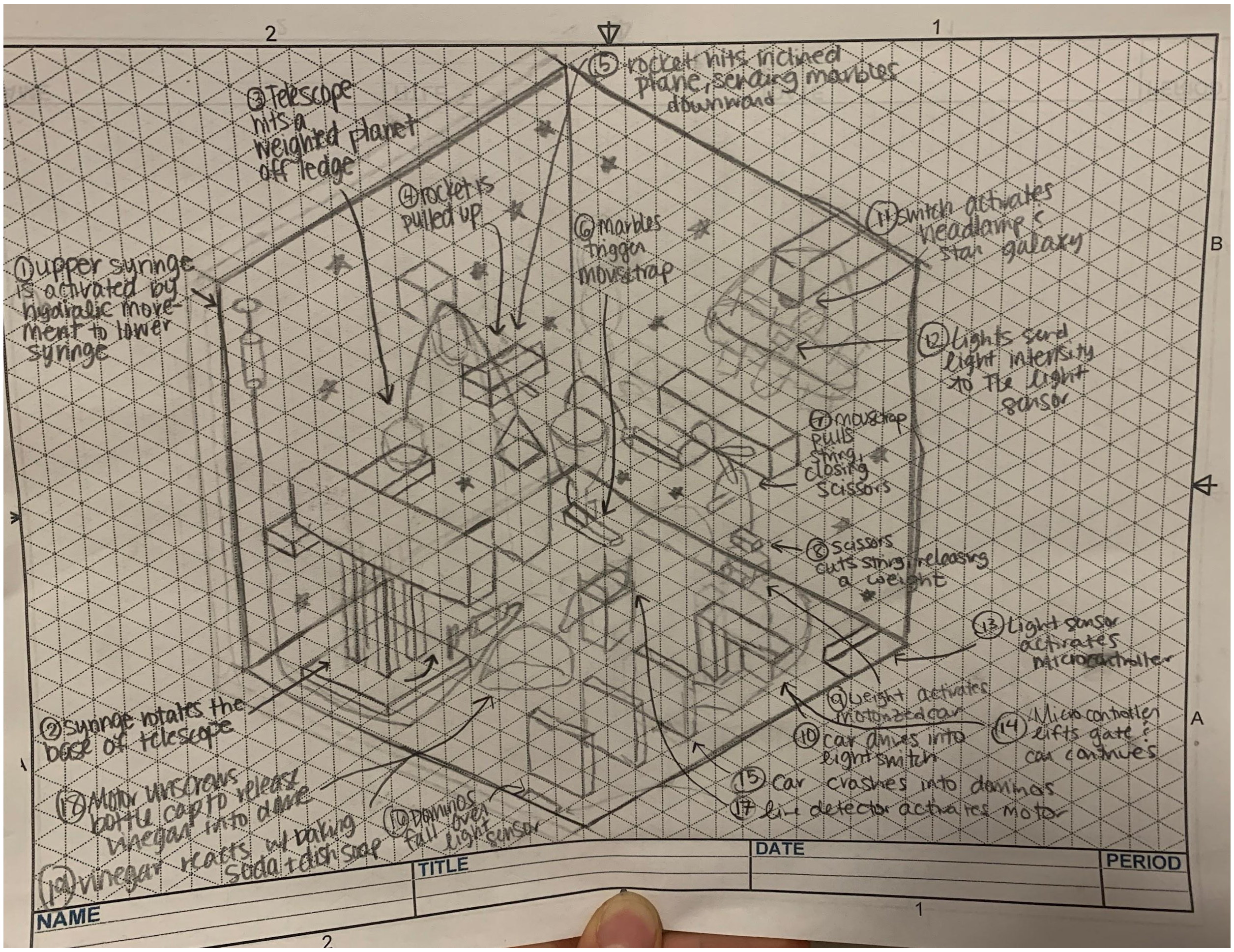


Machine Operation Description:

The first step of the machine is our fluid power component. The syringe at the top left of the machine is pushed down causing the syringe connected to the base of the telescope to rotate. The top of the telescope then hits a weighted planet attached to a string, which proceeds to be knocked off of its pedestal. Since the planet is heavier than the hand-made bottle rocket, the fixed pulley system would become activated, launching the rocket into the air as the planet falls to the ground. The rocket then hits a bar, making an inclined plane with a marble on it, causing the marble to fall into a funnel beneath it and trigger a mouse trap. The mouse trap then pulls a string attached to scissors, pulling them shut. After the scissors are closed, a string is cut, which has a magnetic weight attached to it. The magnetic weight falls into the car below it, triggering the car to run and hit a lightswitch, which turns on. The stars and a headlight light up. A light sensor on the International Space Station receives the light reading. After, the microcontroller sends a signal to lift the lightswitch, allowing the car to pass through. A domino effect begins, starting with the car hitting a box, and activating a line detector sensor. Once the sensor receives the correct reading, the microcontroller sends a signal to the motor. The motor then unscrews a bottle cap and releases our chemical solution into a clear dome, representing Mar and finalizing our machine.

List of Machine Steps

1. The upper syringe in the top left corner is activated by hydraulic movement to lower syringe **(fluid power component)**
2. The lower syringe pushes the base of the telescope, which rotates the telescope
3. The telescope hits a weighted planet off a ledge
4. The planet is attached to a pulley and as it falls, it causes a change in direction and pulls a rocket up **(mechanical component - pulley)**
5. The rocket hits a board, creating an inclined plane and causing the marbles to travel downward and into a funnel **(mechanical component - inclined plane)**
6. The marbles trigger a mousetrap
7. The mousetrap pulls a string, which closes a pair of scissors **(mechanical component - wedge)**
8. The scissors cut a string which releases a magnetic weight
9. The weight hits a lever switch which activates a motorized car **(mechanical component - wheel and axle)**
10. The car drives into a light switch
11. The switch activates a headlamp and star galaxy **(electrical component)**
12. The light from the headlamp sends light intensity to light sensor
13. The light sensor activates microcontroller **(electrical component)**
14. The microcontroller lifts the gate, causing the car to continue driving along the track
15. The car crashes into a series of dominoes **(mechanical component - lever)**
16. The dominoes fall over a line detector sensor, which activates the microcontroller
17. The microcontroller activates a motor connected to the plastic bottle
18. The motor unscrews the bottle cap to release vinegar into a clear dome which holds baking soda and dish soap **(mechanical component - screw)**
19. The vinegar reacts with the mixture of baking soda and dish soap to produce a fizzing foam **(chemical component)**

Cost of Machine and Percent of Recycled Materials Used

Wood (excluding walls)	LED Lights	Wiring
Food coloring	Scissors	Light switches
Studs	Magic Tracks® track and car	Weights
Construction paper	Cardboard boxes	Hinges
Screws	Tissue paper	Plastic bowl
Syringes	Marbles	Magnets
2-liter bottle	Plexiglass	Modeling clay
Pulleys	Cardboard (tubes, pieces)	Carabiner
String, ribbon	Plastic bottles	Headlamp
Funnel	Wooden dowels	Foam
All VEX parts	Epoxy, hot glue, wood glue	Cotton Balls
Ruler	Corrugated Plastic	Foam
Hooks	Batteries	Duct tape, masking tape, electrical tape
Dish soap	Wooden walls and Base	Staples
Water	Vinegar	Mousetrap
Paint	Baking soda	

Red text: reused/recycled materials from our Engineering Lab or homes

Total cost of machine: $75.53

Percent of recycled materials used: 78.72%

Applied STEM Processes

Chemical Reaction Component

Our chemical reaction is the product of the acid-base reaction sodium bicarbonate and acetic acid. Sodium bicarbonate is more commonly known as baking soda and is represented by $NaHCO_3$. Acetic acid is more commonly known as vinegar and is represented by $C_2H_4O_2$.

$$C_2H_4O_2\,(l) + NaHCO_3\,(s) \rightarrow NaC_2H_3O_2\,(l) + H_2O\,(l) + CO_2\,(g)$$

When sodium bicarbonate and acetic acid combine, two chemical reactions happen quickly--double replacement and then decomposition. First, the "acetic acid in the vinegar reacts with sodium bicarbonate to form sodium acetate and carbonic acid" in a process of double replacement (Helmenstine).

$$NaHCO_3 + C_2H_4O_2 \rightarrow NaC_2H_3O_2 + H_2CO_3$$

Secondly, because carbonic acid is unstable, it goes through a decomposition process in which it is broken down into water and carbon dioxide (Helmenstine). Physically, this reaction is shown through foam and bubbles produced by carbon dioxide (Hoyt).

$$H_2CO_3 \rightarrow H_2O + CO_2$$

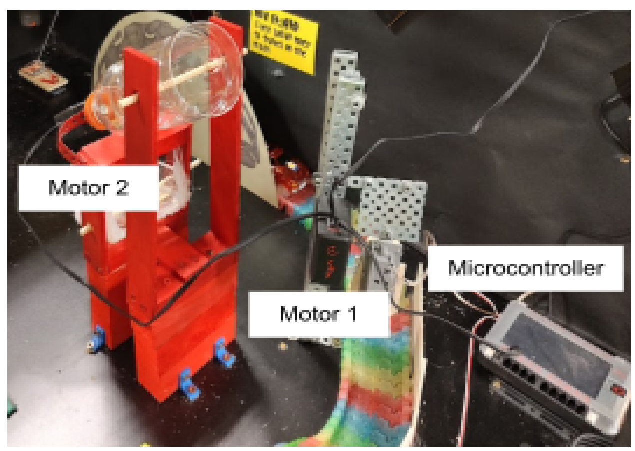
In addition to bicarbonate acid and acetic acid, we decided to add dish soap to our chemical reaction because of previous research. Initially, we planned to make elephant toothpaste with active yeast, warm water, hydrogen peroxide, dish soap, and food coloring, however, we discovered that the dome was not suitable to trap the gas needed to produce a physical reaction. In our research for that reaction, we learned that the dish soap was important because it provided tension for the bubbles, preventing them from popping (Finio). Because of this previous knowledge, we used trial and error to implement dish soap into our current acid-base chemical reaction. In the end, the dish soap proved to have the same effect in both chemical reactions by preventing the bubbles from popping.

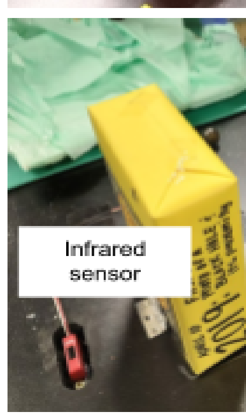
Electrical Components

Our first electrical step uses a photoresistor. A photoresistor is a type of resistor that changes its resistance depending on how much light is shining on it. It is made of a special material that has the property of being more or less conductive depending on the amount of light it receives (“Photoresistors”). Based on the amount of light the photoresistor receives, an analog signal is sent to a microcontroller. After the lightswitch is activated, a headlamp and the star galaxy are activated. The headlamp is positioned above the photoresistor, so when it turns it, a reading is quickly sent to the microcontroller. This change of light is programmed into the microcontroller, which turns “motor 1” 100 degrees when it receives this signal. The result is the car continuing on the track.

Our second electrical step is based on an infrared sensor, which is “an electronic device used to measure and detect infrared radiation in its surrounding environment” (Prabhu). Infrared radiation is then defined light with wavelengths longer than what meets the visible eye (Prabhu). After we connected an infrared sensor to the microcontroller, it was necessary to connect the sensor to one of the microcontroller’s input pins. As the infrared sensor is triggered, we know it will either pull the input pin high or low depending on the configuration. The microcontroller can then read the state of the input pin to determine whether an infrared sensor has been triggered. Because the infrared sensor and microcontroller were connected, we used a software we have access to through our school to monitor the state of the input pin. Depending on the reading, we can inform the microcontroller how to respond by writing a program. In our case, as the microcontroller receives a reading from the falling dominos, the microcontroller is programmed to start rotating “motor 2,” which starts the chemical reaction process.

```
wall = 0
citylights = 0
pneuma = 0

def Headlamp():
    global wall, citylights, pneuma
    while not FlashLight.brightness() > 79:
        wait(5, MSEC)

def Book():
    global wall, citylights, pneuma
    while not LineTrackerBook.reflectivity(PERCENT) > 30:
        wait(5, MSEC)

def CarBlock():
    global wall, citylights, pneuma
    wait(0.5, SECONDS)
    Carblock.set_velocity(10, PERCENT)
    Carblock.spin_for(FORWARD, 100, DEGREES, wait=True)
    Carblock.stop()

def chemical():
    global wall, citylights, pneuma
    wait(2, SECONDS)
    chemical.set_velocity(50, PERCENT)
    chemical.spin(REVERSE)
    wait(4, SECONDS)
    chemical.stop()

def when_started1():
    global wall, citylights, pneuma
    wait(2, SECONDS)
    Headlamp()
    CarBlock()
    Book()
    chemical()

when_started1()
```





Mechanical Components

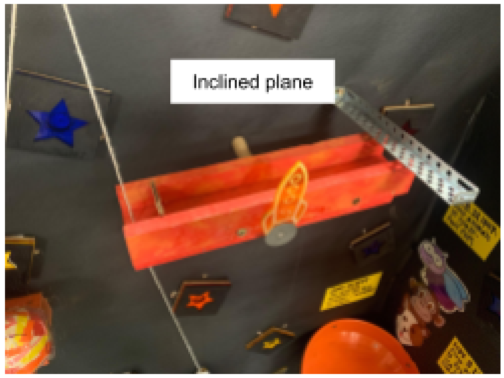
Our machine features the use of **all six simple machines** including, levers, a wedge, a pulley, wheel and axles, a screw, and an inclined plane.

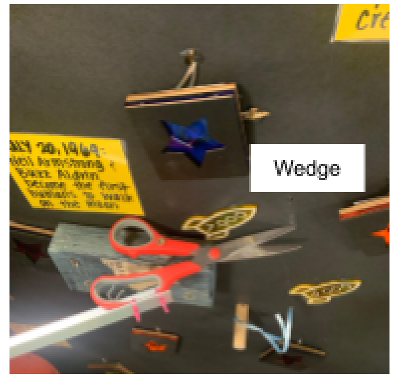
First, our machine contains a fixed **pulley**, in which a wheel is mounted on a fixed axle. We threaded a string through the groove of the wheel with one end attached to the effort force (weighted planet) and the other attached to the load force (rocket). When the effort force of the planet is applied, the pulley rotates on its fixed support, and the load force is shot straight up. In doing so, the direction of energy is transferred as well. This pulley system does not provide any mechanical advantage, as the effort force is heavier than the weight of the load force.

Once the rocket lifts up, it displaces an **inclined plane**, which is a sloping surface. Our inclined plane acts as a marble ramp. As it tips, marbles fall into a funnel and land on a mousetrap underneath. As the mousetrap is triggered, the trap pulls a string that is attached to a pair of open scissors, causing it to close down on a string that holds a small magnet. The scissors act as a **wedge** because it is comprised of two inclined planes. Additionally, because the output force is greater than the input force, the mechanical advantage is greater than one. As the scissors closes, it cuts a string that has a magnetic weight attached to it, and the magnetic weight lands on a 2nd class **lever**. The lever is connected to a switch on a motorized car, which turns on as the lever is hit. This motorized car contains the **wheel and axle**, which has a high mechanical advantage because the axle's radius is much smaller than the radius of the wheel. The car will continue on the track and drive up a ramp, knocking a series of dominos over. The dominos are second class **levers** because the load force is between the effort force and fulcrum.

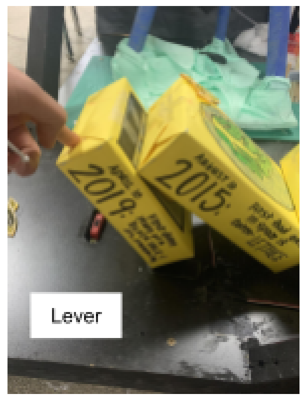
Later in the run, a program from the microcontroller is sent to a motor, which unscrews a cap from a bottle. This system acts as a **screw**, an inclined plane around a cylinder. A special property of this screw is it changes the motion from rotational to linear, which is vital to our design because this bottle releases the reactants for our chemical reaction.


Fixed
pulley

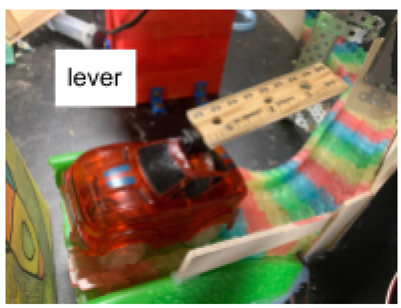

Inclined plane


Wedge


Wheel and axle


Lever
2019
2015

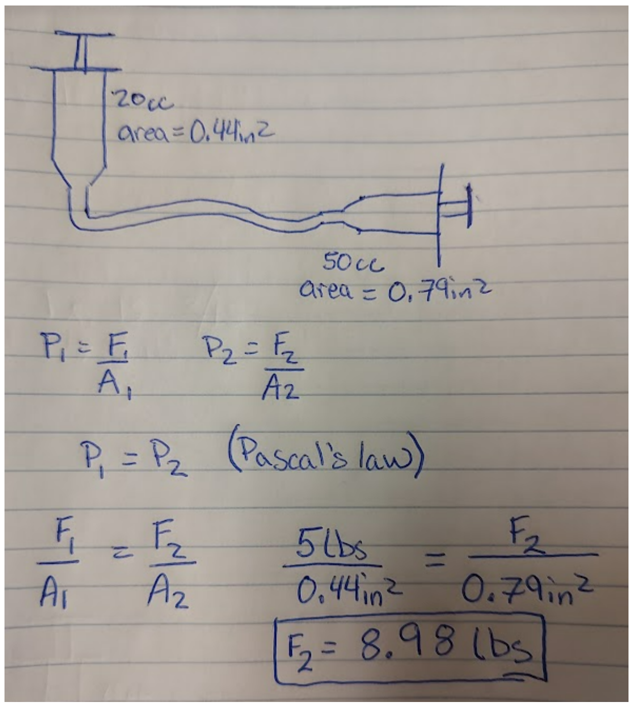

Screw

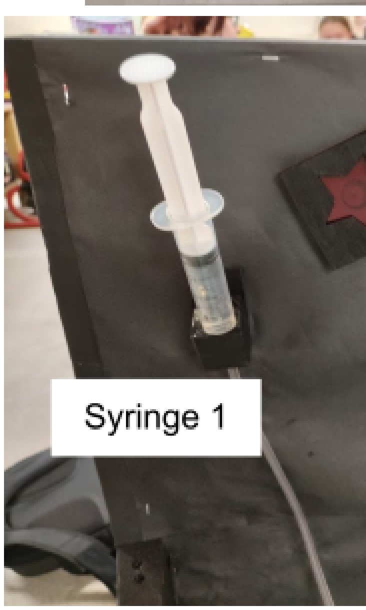

lever

Fluid Power Components

Our machine starts off with a hydraulic water system that includes two syringes. The first syringe, a 20cc syringe, represents a linear actuator, which is a “means for converting rotational motion into push or pull linear motion” (“Linear Actuators”). When this syringe is pressed down, it sends water into the 50cc syringe, which in turn, rotates the telescope.

According to Pascal's Law, a change in pressure is equally distributed throughout the system, and pressure equals area divided by force. Therefore, when we use a 20cc syringe to move a 50cc syringe, it increases the force. This increase of force is needed to assist with moving the large telescope. When we put 5 lbs of force into syringe 1, due to Pascal's Law, syringe 2 pushes at 8.3 lbs. With this extra force the telescope is easily able to move!





Reflection

Word Count: 1497

Throughout the process of building our machine, multiple challenges arose pertaining to the materials and application of engineering principles. Beginning with the process of brainstorming, then moving to creating our steps, testing, and revising to reach our final machine design, we were able to use creative thinking to resolve these challenges and achieve success on numerous levels. This was in part due to our time spent in the research and planning stage. We started planning in October of 2022 and met once every school week to work on elements of our machine until it was completed in March of 2023. Due to the large size of our team, we divided the tasks and had half of our team work on the base while the others planned out the steps, decided on what materials to use, and delegated roles. As we started building and assembling the steps to our machine in January of 2023, many of our challenges arose. However, working through these challenges as a team introduced us to, and allowed us to, practice various valuable skills ranging from perseverance and communication to technical understanding.

First, we had challenges with our fixed pulley system. In the beginning, when the pulley was activated, the rocket would not always hit the inclined plane. To solve this problem, we drilled a hole through the inclined plane to feed the string through, so when the input force of the planet pulls the rocket up, it is guaranteed to hit the inclined plane consistently. We also had troubles with the imbalance of weight in this pulley system. Initially, the planet was far too heavy, which would cause the inclined plane to be hit with a large amount of force and fling the marble too hard against the wall. To fix this imbalance of weight, we added marbles to the rocket to decrease the weight disparity. As we worked through this problem, we were reminded of the principles of mechanical advantage. By minimizing the weight disparity between the input and output forces, we achieved a greater mechanical advantage. With this knowledge of mechanical advantage, we applied a similar concept to the fluid power components using Pascal's Law. In order to reach a high mechanical advantage, we started with a smaller syringe, which had a small input force, and fed it into a larger syringe, which in turn, produced a greater output force because the change in pressure was constant throughout the system. This change resulted in a greater mechanical advantage because the output force was larger than the input force.

In addition, the motorized car, which is a crucial part of our machine design, required us to use engineering principles to knock over our box dominoes and activate the line sensor. At first, we tested the car and the boxes on a flat plane and saw that the car could not knock them over and instead moved "through" the boxes. To combat this, we used a bridge cut in half to get the car higher and fixed the boxes to the base with tape. Attaching these boxes created a second class lever, in which the load force is between the fulcrum and effort force. This change allowed us to avoid adding weights to the bottom of the boxes and also solved another problem of the motorized car driving off of the machine. As the machine ran more and more, the tape started peeling off, so we replaced it with hinges, which made our sensor guaranteed to be hit every time and increased accuracy. From this experience, we were reminded of the principles of trial and error to provide improvement. This concept was a crucial learning point because many of us will be pursuing careers in mechanical, chemical, or aeronautical engineering. While trial and error can be tedious, we relied on this principle for consistency and accuracy. As we enter these fields in the future, we won't be discouraged from challenges and failures because we know how to persevere through them. For those of us who will be pursuing careers outside engineering, this point remains crucial because perseverance and accuracy are necessary for all levels of success.

Given the materials of our machine, we also had to consider safety when building and running trials. We use a mousetrap in our machine, and although it is not inherently dangerous, the string connected to it has to be very taut, meaning it could spring unexpectedly if not handled carefully, so we wanted to come up with a safer way to reset the machine. At first, we decided to duct tape the bottom of the trap, so it could be removed, reset, and then stuck back in the same spot. This was not ideal as the duct tape would move slightly every time we took the mousetrap off and eventually stopped being sticky. We then glued magnets on the base of the machine and the bottom of the mousetrap. This allowed for easy removal, and we could safely hold the mousetrap from the bottom/sides when pulling the string taut. The standard mousetrap, however, was not durable enough to withstand numerous trials, and over time, it would not spring with enough force, or the metal would become deformed. In reflecting upon this problem, we learned about the relationship between stress and strain: the more stress and strain, the closer the object gets to fracture, in which case the object is broken. To prevent fracture and ensure safety, we chose a more durable mousetrap. This challenge highlights the communication our team learned because it took numerous discussions to brainstorm and reach a successful solution. It also involved most of our team members, so we had to communicate different updates. Additionally, with the numerous changes that this step undertook, it also demonstrates our perseverance of keeping with our original design and improving it to make it better instead settling on a step that was inaccurate.

Our biggest challenge towards the end with the machine was getting our chemical reaction to work. This final step was the least planned out and thus resulted in a full circle of the engineering design process. We started by thinking about what we wanted it to look like, and we settled on a fizzy and expansive reaction to emulate Mars in our timeline themed machine. We began our research and decided to do a yeast, warm water, hydrogen peroxide, dish soap, and food dye reaction, but we found out through our test runs that this was not feasible for the large reaction that we were seeking. With the shortage of hydrogen peroxide, the sheer amount of each ingredient needed, and the containers that we had, this chemical reaction was not going to work. After our testing phase and ultimate conclusion, we turned back to our research to try and come up with a different reaction to reuse the same containers that we already had. This is when our team members decided to test a couple of known reactions and ended up with a combination of baking soda and vinegar. Due to the research we conducted for our original chemical reaction, we knew that adding dish soap would provide tension to keep the bubbles from popping. This technical knowledge allowed us to persevere through challenges and end up with our desired chemical reaction. It also relates to future engineering studies because lots of projects start with a working prototype, but changes are made to improve the cost, usability, or other factors. These changes are based on previous knowledge and research, just like our chemical reaction. Because we did not want a simple baking soda-vinegar reaction, we used previous knowledge to enhance it, a process many of us will continue to use throughout our studies and careers.

In light of our challenges, we experienced numerous successes with our machine design. One of those is with the sequence of activating the mouse trap to the scissors closing to cutting a ribbon to a weight hitting the motorized car. Once we firmly secured everything and measured out the correct lengths for the string connecting the mousetrap and scissors to be taut and long enough to hit the motorized car, it all worked as planned. Tiny successes like these can be attributed to our long planning phase and dedication to thinking about how our machine is going to work before jumping head first into assembling the steps. This was a skill that returning members learned from last year as we struggled at the last minute to connect all of our steps because our planning phase wasn't as productive.

As a whole, our team experienced numerous challenges throughout the building of our machine, however, due to a wide array of specialties and communication between members, we also experienced a lot of success. Through perseverance and newly acquired skills such as technical understandings, our team experienced a level of growth that extends far beyond the completion of our machine and can be thoroughly applied in whatever career we choose to pursue.

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