Advancing Technology By Reverse Engineering the Body

St. Ansgar High School

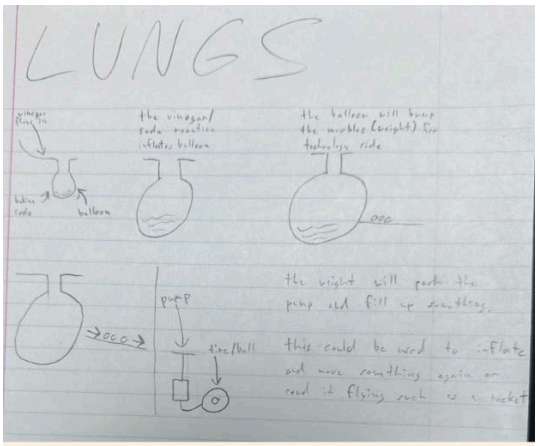
Team Members: The Medical Mob
Kinsey Anderson
Max Beland
Hannah Clevenger
Aspen Falk
Kaelee Hicken
Morgan King
Alex Lenz
Drew Powers
Carsen Sparrow

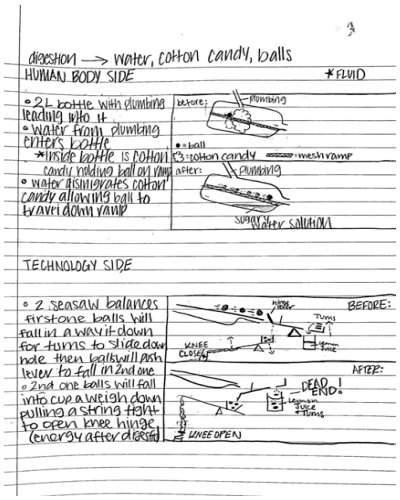
Contest Theme:
Advancing Technology By Reverse Engineering the Body

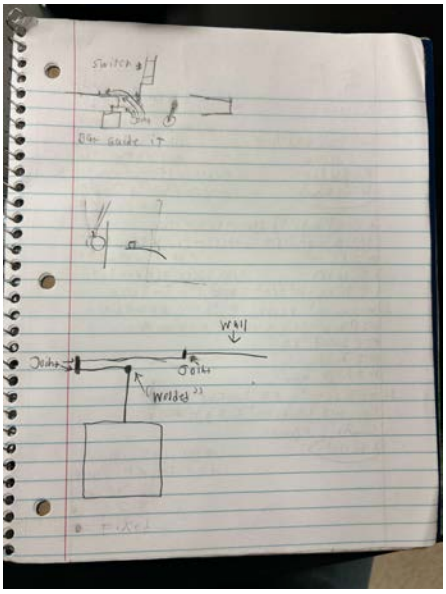
Table of Contents

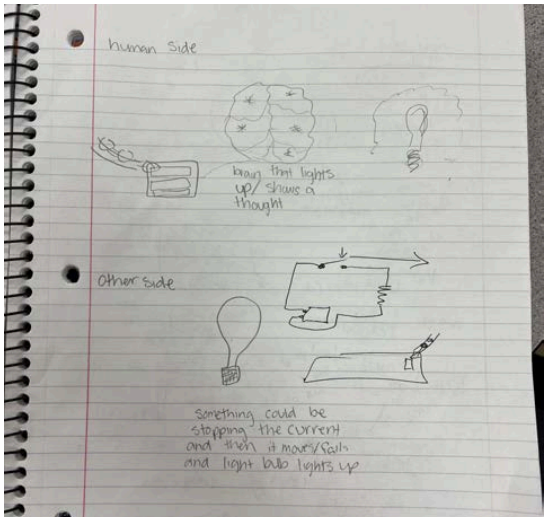
1. Planned Machine Design Sketch and Description

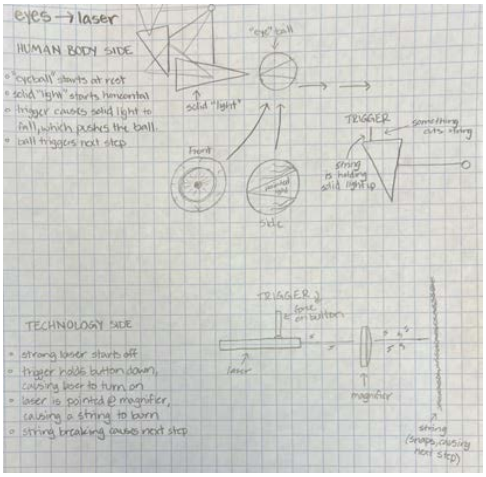
Drawings of steps:

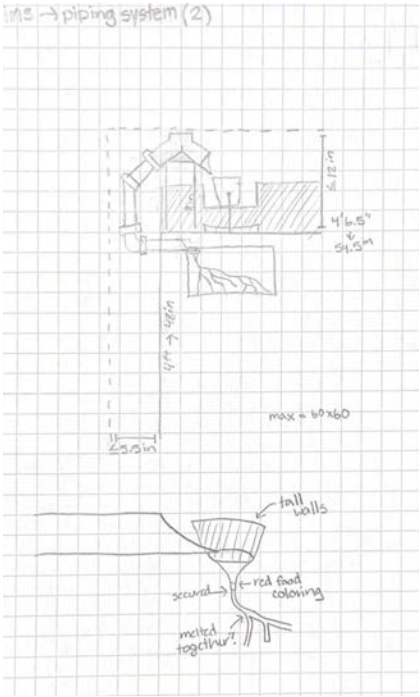


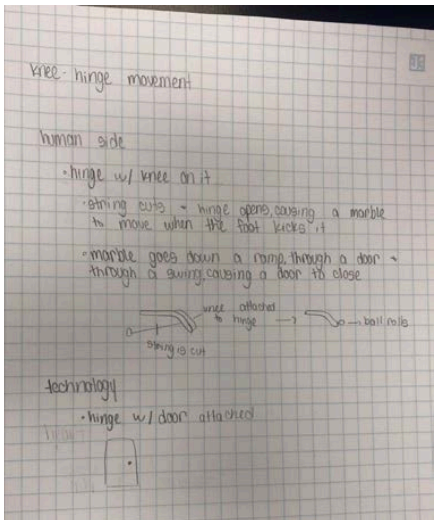


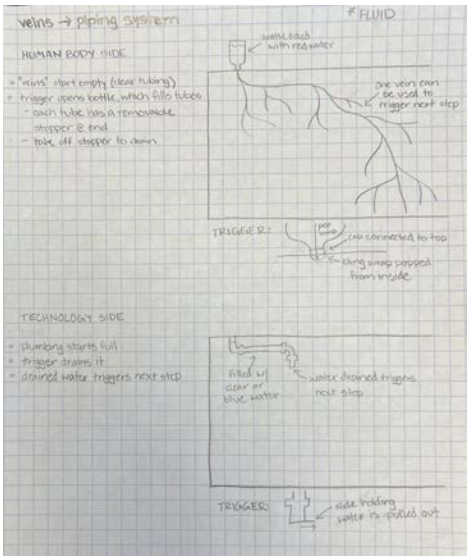


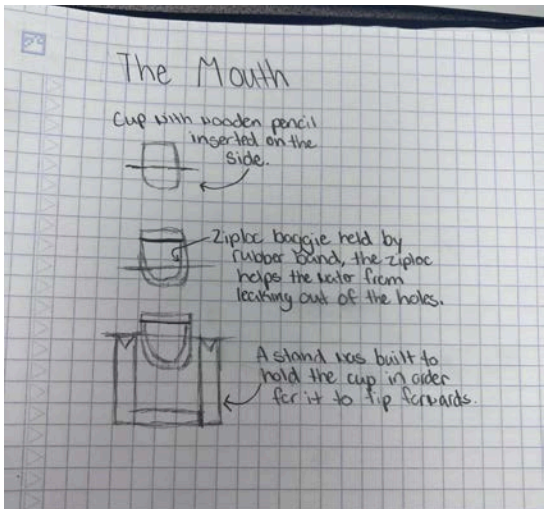


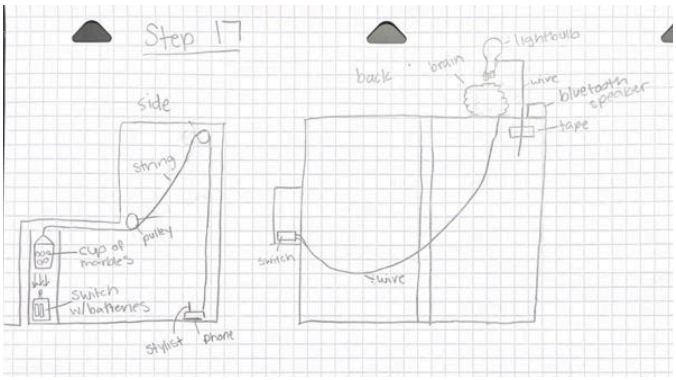


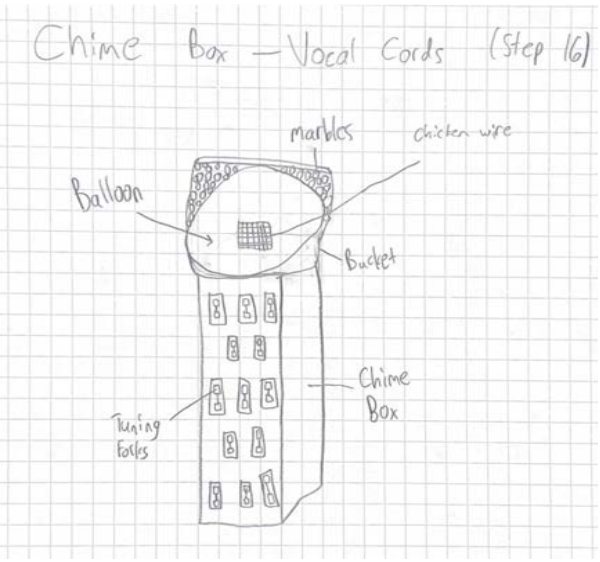


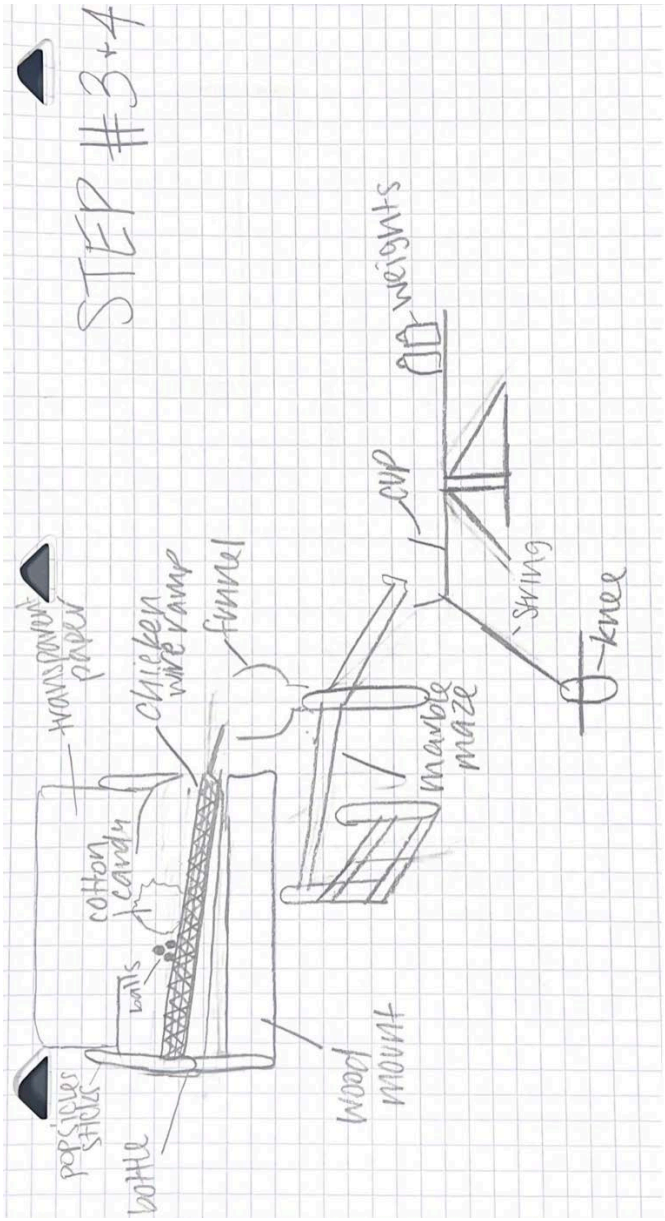


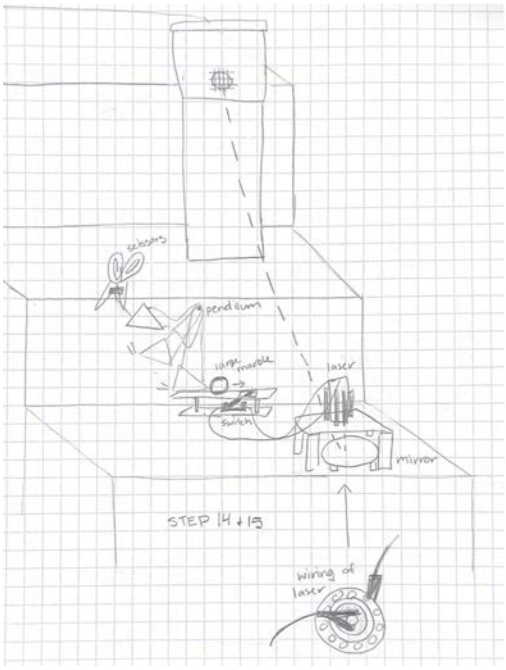



The Mouth
Cup with wooden pencil inserted on the side.
Ziploc baggie held by rubber band, the ziploc helps the water from leaking out of the holes.
A stand was built to hold the cup in order for it to flip forwards.


Step 17
side
back
string
pulley
cup of marbles
switch w/batteries
stylist
phone
lightbulb
wire
bluetooth speaker
tape
switch
wire


Chime Box – Vocal Cords (Step 16)
marbles
chicken wire
Balloon
Bucket
Chime Box
Tuning Forks


STEP #3+4
weights
cup
string
knee
transparent paper
chicken wire
funnel
marble maze
cotton candy
balls
wood mount
popsicle sticks
bottle

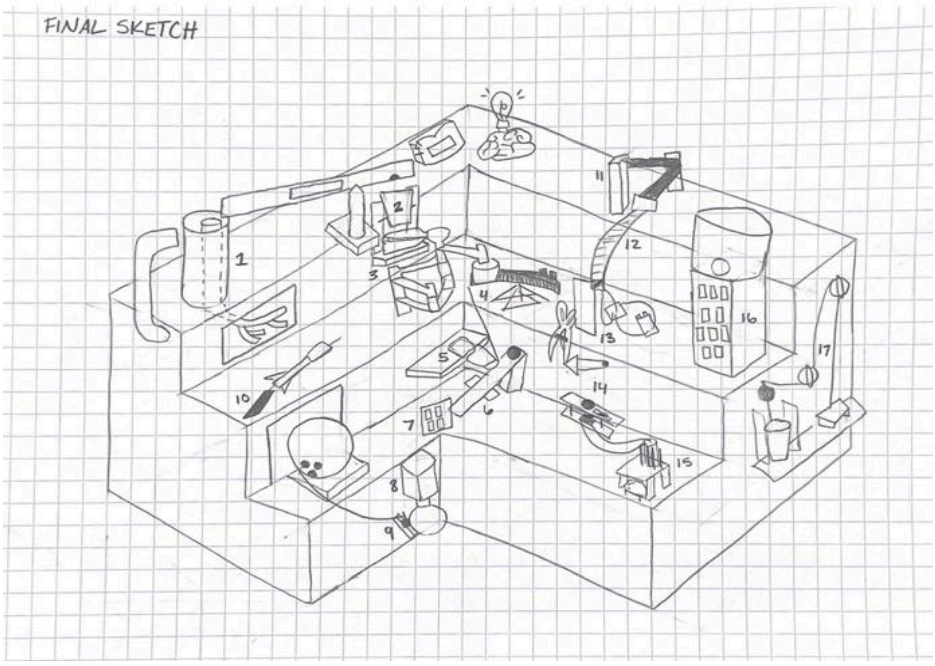

scissors
pencil
laser
switch
mirror
STEP 14 & 15
wiring of laser

2. Final Design of Project

Complete run-through:
https://drive.google.com/file/d/1_Erqp5RTG47Yk8CBfYOhpGAX1EzLBpe5/view?usp=sharing

- Above is a link to a complete run-through of our project. This video clearly shows the transfer of energy that takes place in each step.

- Along with this, below is the sketch we had for our final design, along with a picture of the completed project that contains clearly labeled steps.



3. List of Machine Steps

Step 1: Team member pours water into PVC piping. The water goes into clear tubing to represent the veins, and the rest travels down the PVC pipe and dumps into the blue cup.
Step 2: The water from the piping fills up the cup. The cup, which has weights on the bottom, begins to tip and the water dumps out of it.
Step 3: The water falls onto the cotton candy holding marbles. The water dissolves the cotton candy, causing the marbles to be released and travel down the bottle.
Step 4: The marbles fall into the funnel and travel down the marble maze. They land in a cup, which is sitting on a teeter-totter. Once the marbles land in the cup, they release the tension on the string, causing the knee to open.
Step 5: The knee opens and the ball attached to it lands on a mouse trap. The mouse trap has a string that pulls out a pin.
Step 6: The pin, holding up a marble, falls and the marble is released. The marble rolls down the ramp and runs into the door, causing it to open.
Step 7: The door opens which then causes a bottle, which is filled with vinegar and has a balloon with baking soda in it attached to the top of it, to tip. The bottle tipping causes a chemical reaction between the vinegar and baking soda to take place, which blows the balloon up. (Chemical Step)
Step 8: As the balloon blows up, it tips a weight off of the ledge it sits on. This weight is attached to a bar that is holding a bowling ball in place. The weight falls off and the pin is released.
Step 9: Once the pin is released, this causes the bowling ball to fall through the hole and into a bin, landing on a rocket launch pad. (Fluid Power Step)
Step 10: The launch pad is compressed, which causes the rocket to be launched. (Fluid Power Step)
Step 11: The rocket, attached to a string, hits a post that has a metal ball resting on it. The force causes the golf ball to fall down a ramp.
Step 12: The metal ball hits our toy character, sending him down his tube. When the character reaches the bottom of the tube, it flips a switch. (Electrical Step)
Step 13: The switch flip causes the scissors to move, cutting a string that is holding a triangle that acts like a pendulum. The triangle piece runs into a golf ball.
Step 14: The golf ball moves down a track and flips a switch. The switch causes the laser to turn on.
Step 15: The laser turns on. It reflects off a mirror (the angle of incidence is equal to the angle of reflection), causing the beam to be aimed at a bucket holding a balloon. The balloon is sitting inside a bucket and is surrounded by marbles. The balloon pops and the marbles fall.
Step 16: The marbles fall into the sound chamber. They hit the tuning forks and create sound, then fall through a hole in the project into a tube that dumps them into a cup. The cup is weighed down.
Step 17: When the cup, which is on a pulley system, is weighed down, it pushes a battery into place, causing the lights to turn on. It raises the other end of the pulley system, pulling the iPhone stylist up, causing the play button to be released and play music. (Mechanical Step)

4. Material Log

Item	Quantity	Origin	Price
Base from previous project	1	Recycled	$0.00
White paint (Base Coat)	1 Gallon	Purchased	$36.99
Painting brushes	3	Purchased	$4.99
Tarp	2	Recycled	$0.00
Spray Paint	1	Mr. S	$0.00
3D Printed Door	1	Mr. S	$0.00
3D Printed Knee	1	Mr. S	$0.00
Hinges	2	Mr. S	$0.00
Plastic Bottles	2.5	Recycled	$0.00
Balloons	16	Mr. S	$0.00
Blue Plastic Cups	2	Recycled	$0.00
Mouse Traps	2	Mr. S	$0.00
PVC Piping	5	Mr. S	$0.00
Large PVC Pipe	1	Purchased	$7.99
Marbles	≈60	Mr. S	$0.00
Marble Maze Pieces	12	Mr. S	$0.00
Plywood	1 large piece	Mr. S	$0.00
Duct Tape	1 roll	Mr. S	$0.00
Screws	75-100	Mr. S	$0.00
Weights	3 (different masses)	Mr. S	$0.00
Pullies	2	Mr. S	$0.00
String	1 roll	Mr. S	$0.00
Fishing Line	1 roll	Mr. S	$0.00

Rocket Launcher toy	1	Mr. S	$0.00
Brain	1	Amazon	$10.99
Golf Ball	2	Mr. S	$0.00
Large Marbles	2	Mr. S	$0.00
Cotton Candy	2	Amazon	$8.99
Chicken Wire	4x6 inch piece	Mr. S	$0.00
Race Car Tracks	2	Mr. S	$0.00
Plastic Light Bulb	1	Mr. S	$0.00
Electrical Switch	2	Mr. S	$0.00
Wires	Several various pieces	Mr. S	$0.00
Baking Soda	1	Purchased	$1.50
Vinegar	1 bottle	Purchased	$3.93
Clear Piping	1 roll	Amazon	$8.89
Mirror	1	Mr. S	$0.00
Petri Dish	1	Mr. S	$0.00
Clear Tub	1	Mr. S	$0.00
Bowling Ball	1	Mr. S	$0.00
Popsicle Sticks	2	Mr. S	$0.00
Rubberbands	4	Mr. S	$0.00
Tuning Rods	13 (all different lengths)	Mr. S	$0.00
Clear Transfer Paper	1 sheet	Aspen	$0.00
Batteries	3	Mr. S	$0.00
Cotton Balls	2	Mr. S	$0.00
Plastic Cup	1	Recycled	$0.00
Supports	8	Mr. S	$0.00

Laser	1	Amazon	$49.99
Dominos	2	Mr. S	$0.00
Foam Pads	2	Mr. S	$0.00
Hot Glue Guns	3	Mr. S	$0.00
Hot Glue Sticks	≈60	Mr. S	$0.00
Super glue	1 bottle	Mr. S	$0.00
Plastic bag	1	Mr. S	$0.00
Caulk	1	Purchased	$7.49
Eye Hook Screw	3	Mr. S	$0.00
iPhone Stylist	1	Mr. S	$0.00
Toy Figure	1	Mr. S	$0.00
Scissors	1	Mr. S	$0.00
Pink Tubing	1	Mr. S	$0.00
Connects	≈30	Mr. S	$0.00
Colored Paint	3 colors	Mr. S	$0.00
Drill	2	Mr. S	$0.00
Multi-tool	1	Mr. S	$0.00
Hand-held Circular Saw	1	Mr. S	$0.00
Plyers	3	Mr. S	$0.00
Phone	1	Carsen	$0.00

Total Cost: $141.75

Recycled Materials Used

Total materials: 401
Recycled materials: 383
Percent recycled: 95.5%

5. Applied STEM Process/ Advanced Components

Chemical Step: Step #7

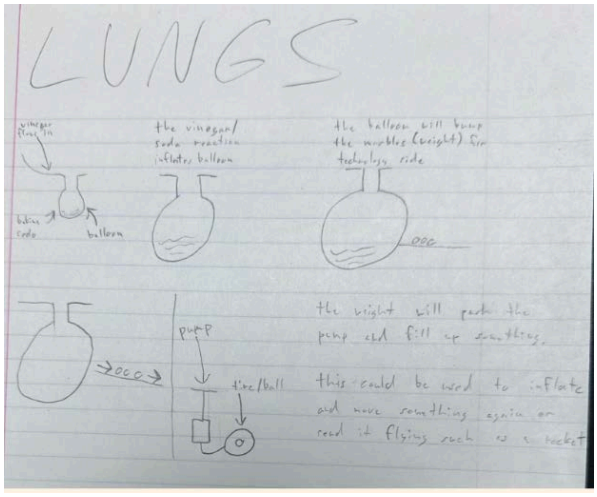
Chemical Reaction

- Reactants
  - Baking Soda (Sodium Bicarbonate)
    - $NaHCO_3$
  - Vinegar (Acetic Acid)
    - $HC_2H_3O_2$
- Products
  - Carbon Dioxide
    - CO_2
  - Water
    - H_2O
  - Sodium Acetate
    - $NaC_2H_3O_2$

Chemical Equation:

$NaHCO_{3\,(S)} + HC_2H_3O_{2\,(l)} \rightarrow NaC_2H_3O_{2\,(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

- The water bottle is filled with the vinegar (acetic acid). On top of it is a balloon that is filled with baking soda (sodium bicarbonate). Once the bottle is tipped over, the baking soda and vinegar mix, causing the chemical reaction to occur and inflate the balloon. Below is a drawing of the initial step, as well as a picture of the finished product attached to our project.

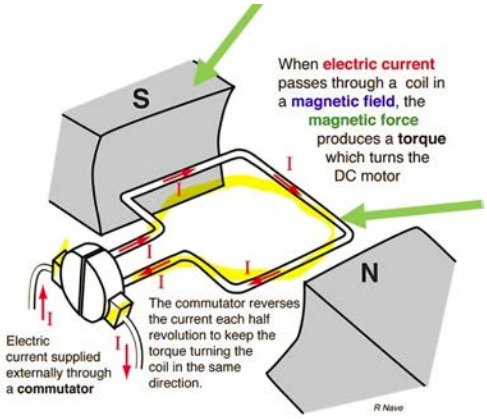


Fluid Power Step: Step #10

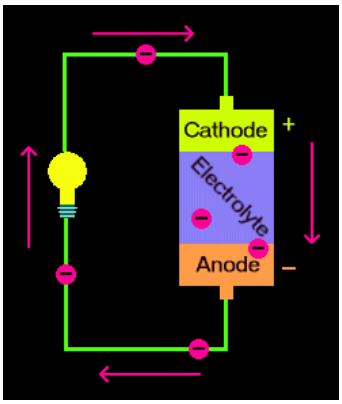
Pneumatics

- F = P x A (Force = Pressure multiplied by Area)
    - Pneumatics has to deal with the mechanical properties of gas and transporting it. For our fluid power step, we are moving water, but in its gaseous state. This is what makes this step our fluid power step. In this step, the bowling ball falls through the hole in the side of our project. The bowling ball is the pressure component of the pneumatic formula. The area component is the area of the rocket launcher. The pressure that is placed on the launch pad causes a force of air to be moved through the tubes and propels the rocket. The power of pneumatics and moving the gas (air) is a crucial part of our project. Shown below is our rocket launcher pad and the rocket that is launched through the process of pneumatics.
- $F_1 / A_1 = F_2 / A_2$
    - F_1 is the bowling ball, and A_1 is the area of the launch pad. The area of A_1 is quite large in comparison to A_2, which is the area of the tubing. Because of this, F_2, which is the force exerted onto the rocket, becomes quite a large force. Through the power of pneumatics and this process, enough force is applied to launch the rocket.

Electrical Step: Step #12



The Electrical step is set off when \ the toy slides down the ramp which is connected to 3D printed parts that I designed with CAD software specifically for this project. These are a spacer and ram, the ram hits the switch at the bottom of the tube. This switch then closes and the circuit is complete, the switch is connected to a DC motor and 9 v battery. The battery works by converting the chemical energy into electrical energy. The electrons flow out of the anode (-) of the battery through the circuit to the cathode (+). A medium inside the battery allows the flow of electricity to pass through it. Once the current reaches the motor it passes through coils which generate an electromagnetic field. The timing of this magnetic field is controlled by a commutator which reverses the magnetic field through the stator to keep the shaft spinning. The electric motor's shaft has a spool attached to it which I designed to slide on using CAD. The spool has string glued onto it which is then connected to a lever on the scissors to get more leverage.

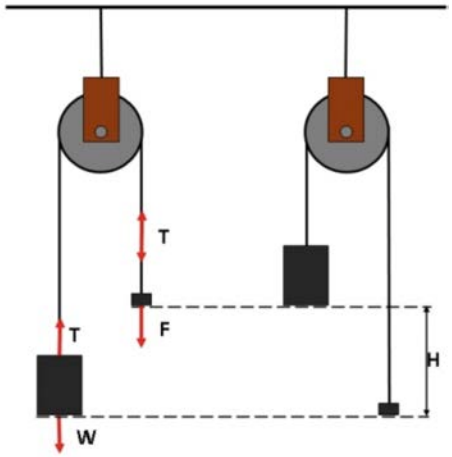


Ohm's Law: Voltage= (Current)(Resistance)

Mechanical Step: Step #17

Pulley

- Mechanical Advantage, M, is M = W/F, where W is the weight and F is the force
    - In our project, to achieve the goal of lifting the iPhone stylist to make the music play, the weight of the marbles must be heavy enough to weigh the cup down. This is displayed in the mechanical advantage formula above, as the force must be great enough to overcome the weight of the mass on the other end of the pulley. This mechanical step of a pulley is an example of a simple machine. We found that the use of this mechanical step in our project is a perfect way to achieve the goal of lifting the iPhone stylist and the platform it's on.



6. Reflection

Kinsey: This project at times was stressful and honestly frustrating. It was challenging to figure out my step initially and think about how it could start the following step. Not only figuring that out, but after trialing I had to change my design multiple times to get accurate results. Through this project, I have learned how the everyday world around me works through physics. I also learned how to overcome challenges and find a solution when problems occurred even if it took time.

Max: If there is one thing I would say about this project, it is that it's very frustrating, yet very rewarding. It took hours of working, both in and out of class, to get everything done. It was always so disheartening to watch one of our steps fail, but we knew it meant we were close and we could get this right.. I need to continue to push forward and try until I get it how I want it. Overall, this project has been a great experience and helped to improve myself and my classmates.

Hannah: This project was not an easy one, that's for sure. Even though at times it was a little stressful and frustrating, seeing the result is a very fulfilling feeling. While figuring out how to engineer my steps was difficult at first, once I started working on it and thinking about it, it became a good experience. I learned there is always a solution to a problem, even if it takes a while to find it.

Aspen: This project has taught me that to be successful, you have to go through the ups and downs. We had very productive days, and days where we felt stuck. We pushed through all the hard days, though, and I'm proud of what we've come up with.

Kaelee: This project was frustrating at times, but once everyone's steps started to come together, there was a successful feeling. This was a great experience for me because I got to learn with my peers and overcome challenges with them as well. I've had a lot of fun while doing this project and I'm glad I got to be a part of it.

Morgan: This project taught me a lot. I had to learn how to push through frustration to finish the project. I also learned how to use problem-solving skills and become more creative. This project was fun in the end even though it caused a lot of stress and frustration. I think the most important thing we did was work together and help each other out to complete the project. You can solve a lot of problems if you communicate and work together.

Alex: I learned a lot from this project, such as patience and problem-solving. It took me a while to think of ways to complete my designated steps, but through determination and looking at it from a different angle, I finally figured it out. All in all, it is one of the most rewarding experiences that I've ever completed and it changed the way I look at the world around me.

Drew: Although it was hard to find time to work on the project outside of class, it was a fun and challenging experience. I personally thought one of the most satisfying parts of the project was when the individual parts started actually to work together. Throughout the project, I learned patience and communication are key when working with others. With the small amount of room we had to work with, it was hard to work on putting multiple steps on the project at once. So, we had to work together and communicate what step was being worked on and when. Overall, I had lots of fun working on this project, and I learned a lot from just the few months we worked on it.

Carsen: I really enjoyed working on this project, even though sometimes it got irritating. My favorite part of this project was solving problems. When there was a problem whether it was my step or a classmate's step it was fun to think of a solution to that problem and watch it work. The hardest part was working with others' steps because we all had stuff going on, it was rare to have everyone there at the same time. Because of this, we could rarely talk about each other's steps together.

7. Bibliography

Dcbradley@wisc.edu. "Pulleys." *L.R. Ingersoll Physics Museum*, www.physics.wisc.edu/ingersollmuseum/exhibits/mechanics/pulleys/.

"Laser Physics Basics." *American Laser Study Club*, 11 Oct. 2021, www.americanlaserstudyclub.org/laser-physics-basics/.

Bates, Mary. "How Does a Battery Work?" *Mit Engineering*, 1 May 2012, engineering.mit.edu/engage/ask-an-engineer/how-does-a-battery-work/

Magnetic Innovations. "DC Motor, How It Works DC Advantages." *Magnetic Innovations*, www.magneticinnovations.com/faq/dc-motor-how-it-works/.

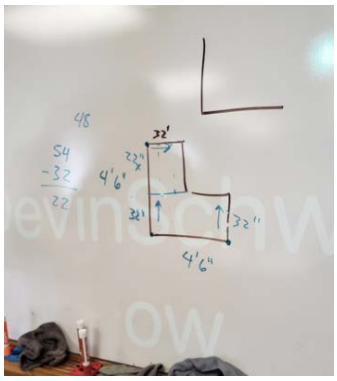
Northwestern University. "How Do Batteries Work?" *Www.qrg.northwestern.edu*, www.qrg.northwestern.edu/projects/vss/docs/power/2-how-do-batteries-work.html.

"Baking Soda and Vinegar." *Primary Connections: Linking Science with Literacy*, www.primaryconnections.org.au/themes/custom/connections/assets/SBR/data/Chem/sub/baking/baking.htm#:~:text=The%20reaction%20is%3A,dioxide%2C%20water%20and%20sodium%20acetate.&text=The%20solid%20baking%20soda%20was,bubbles%20in%20the%20foaming%20mixture.

8. Daily Log: Work Days, Process, and Photos

Day 1: 11/15/23

On the first day, we began to brainstorm ideas for our project. As a group, we decided we wanted our project to be as efficient as possible so we would be able to use the space allotted well. This previous, premade design that has multiple levels is the ideal design for what we wanted. We began to brainstorm hypothetical ideas for this project that are related to the theme.

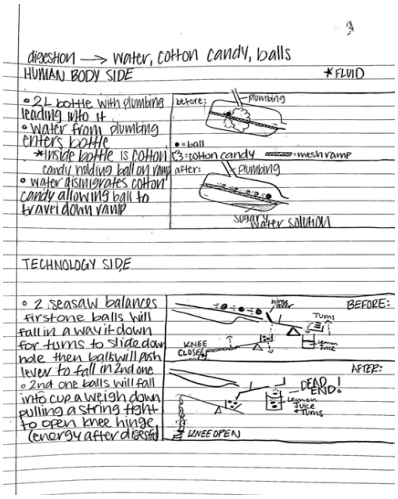


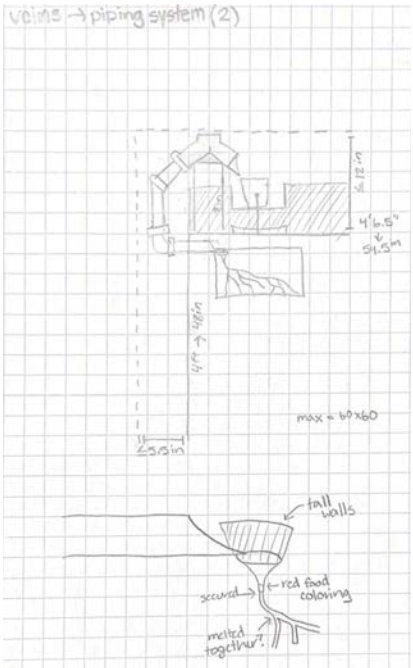
Day 2: 11/21/23

We decided that the project needed a new look and wanted to start the project with a clean slate. Using white paint, we began to paint the project. As we were painting, we discussed a possible game plan for how to begin and started to individually think about our steps. Because there are 9 students in our class, the goal was for everyone to come up with two of their own steps. This would get us the required step amounts with a few extra, so the idea is that if a few people can only think of one step we will still have enough.

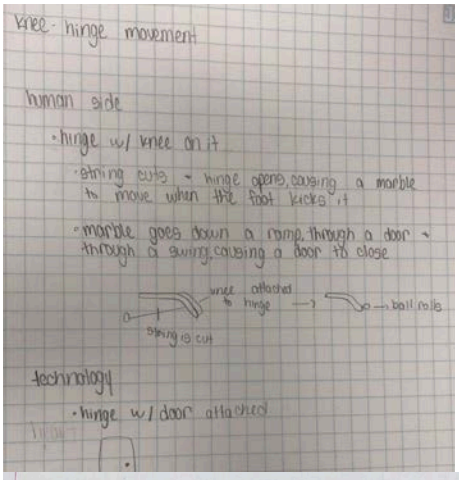
Day 3: 12/6/23

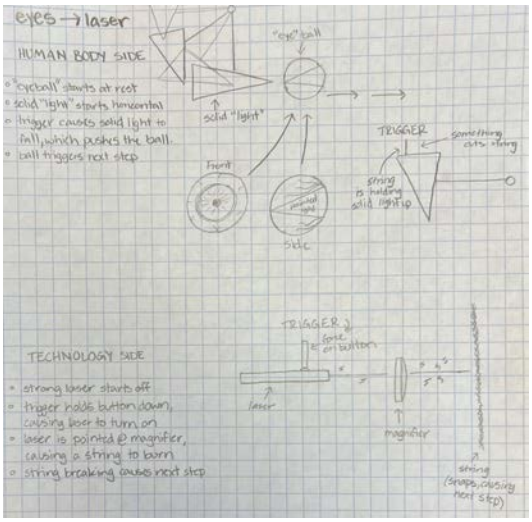
Over Thanksgiving break, we each had a goal to come up with our steps and draw how they would work on a piece of paper. When we came back to school, we had a very good game plan on how to begin working on our project and individual steps. Because we did not have all the resources we needed, we were tasked with figuring out the materials we would need and sending Mr. S a link if anything needed to be ordered. We also decided,

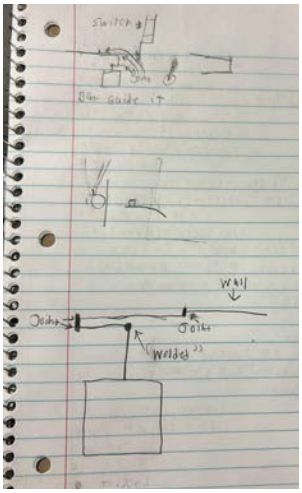


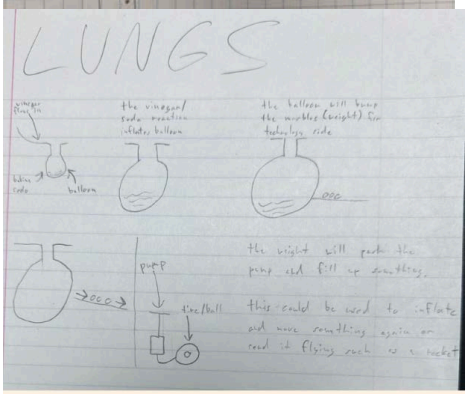


because the theme of the contest is “Advancing Technology by Reverse Engineering the Body”, that all of our steps would have two components – one that deals with how the body works and one that coincides with it in the real world. Some early ideas we had for this were the veins are like a water piping system, the hinge movement that a knee does is like a door, the lungs filling up with air is like a balloon expanding, and the mouth has something to do with water, a step that deals with running, and something dissolving with water is like our stomach acid dissolving our food. Again, these are a few early sketches of some of our ideas that were previously made, before construction of them.







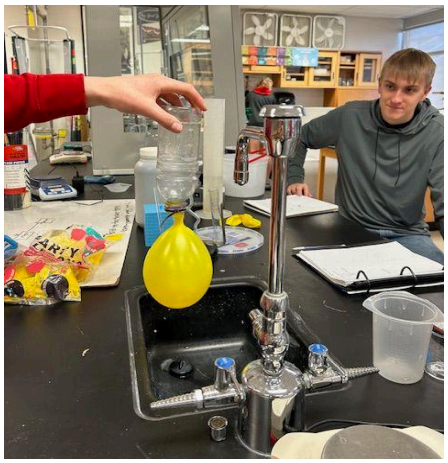


Day 4: 12/18/23

Today we mapped out roughly where things would go on the project as a rough sketch, and cut this hole out in the project as we needed it for one of our steps. Because we didn’t have the entire class time to work, this was all that we did today.

Day 5: 1/8/24

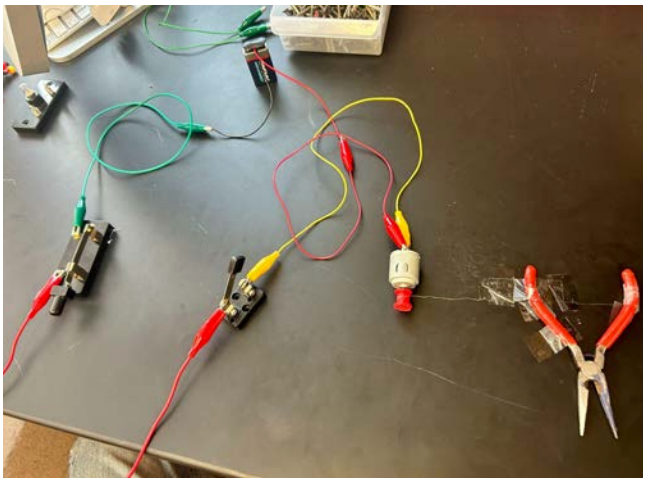
Today we began to actually start making some of the steps, or as Mr. S would call it, “Getting tangible evidence.” We began to build some of our steps. We worked on our chemical step today. The goal for this step is to have a bottle, that contains vinegar, with a balloon, which is filled with baking soda, tip over. The reaction will fill up the balloon. After several trials and errors of figuring out how much of each substance to add, we got the



measurements finalized and the reaction caused the balloon to fill up.

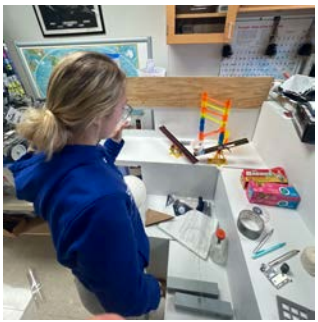
Day 6: 1/10/24

Today was a very productive day. Aspen got her eye painted, which will be used for her step that involves light, and also got her podium set up which will be used for the first step. Hannah also got her 3-D knee printed and the hinge attached, along with her door, which will be used for the hinge steps. Kinsey and Drew also worked on their chemical reaction, and Alex worked on his step, which is an electrical step. It feels really good to actually be making progress.



Day 7: 1/12/24

Many steps are ready to be attached to the project and ready to be connected to the others. This is proving to be one of the most difficult, but also the most fun, part of the project thus far. Having to work together to get results is a rewarding feeling, but can be a little frustrating when nothing seems to be working. However, today we made good progress by attaching parts to the project and finalizing some other steps.



Day 8: 1/17/24

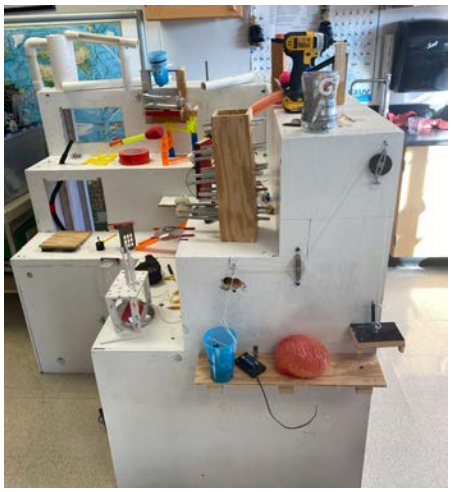
As we attach many of the steps to the project, it is clear that many alterations need to be made to make it all work well together. This is mainly what we focused on doing today.

Day 9: 1/21/24

We are learning that finding time to work on this project outside of class is a difficult task, as we are all heavily involved in many extracurricular activities. However, this weekend, those of us who could make it came in to work on the project. Today was dedicated to connecting our steps.

Day 10: 1/24/24

As we near the end of working on this project, most of our steps are finished and just need to be connected better. That is what we worked on today, as well as working on our journal.



Day 11: 1/26/24

We encountered a few troubles with some of the steps not working today that previously had been. Despite this, we troubleshot different ways to fix this issue to get these steps working smoothly again.

Day 12: 1/28/24

The end is in sight, as the competition date approaches us quickly. Today, we worked on really adjusting our steps to the way we want to make them work well. We also discussed a plan for decorating our project once most of the steps are attached.

Day 13: 1/30/24

Today was a very productive day. As the competition date is in just a few weeks, we spent our day really focusing on getting all the steps attached to the project and perfecting how they work.

Day 14: 2/1/24

Finalizing all the steps on the journal was a very big objective for the day. After Mr. S spent some time talking to us about the competition, we got back to work on the project. We spent a lot of time working on our electrical component, as well as using the laser for more test runs

Day 15: 2/3/24

Today we are finalizing the steps and making sure everything is perfect and running smoothly. While we are finishing up, it is really cool to see all of our hard work being paid off when the entire project works. Although it doesn't look exactly like we though it would in the beginning, the changes we have made along the way make it better, and we are all very proud of our project.

Day 16: 2/7/24

Today we focused on decorating our project to make sure everything looked good. The look of our project was the main problem after getting the individual parts working, because it wasn't appealing to the eye. We worked on brightening some parts up, and overall making the project flow better together.

9. Initial Ideas/ Drawing of Steps

Speaking → AI speaking for us

- Starts with humans speaking
- Ends with AI speaking
    - Judges' voices?

Use Alexa to shake and move something

Breaking down parts of the brain

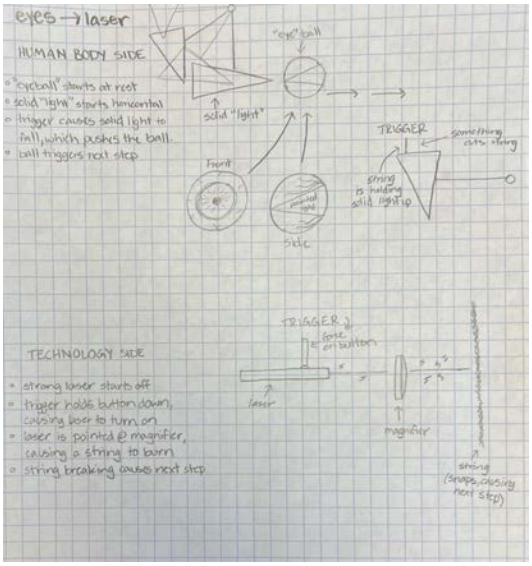
- Midbrain
    - associated with vision, hearing, and motor control

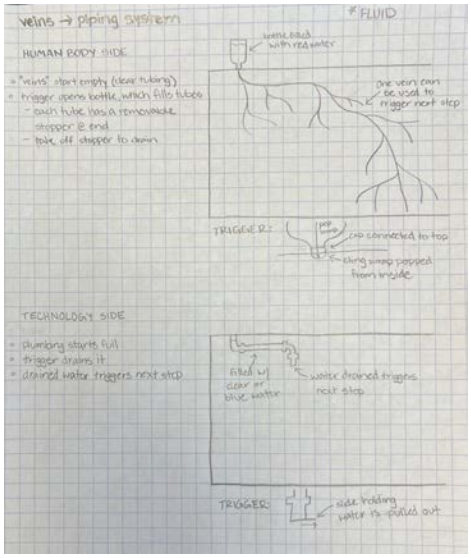
Electrical: pacemaker, LED lights
Brainstorming

- Put human side/ human components on the inside/ back of the display and the technology on the front side
    - What the human body does on the inside affects what we see in technological advances on the outside

Human Body to technology equivalents

Aspen's Steps





Process

Late November

- Initial steps drawn out (shown above)
- Order placed:
    - 3mm x 5mm silicone tubing (10m length) **$19**

https://www.amazon.com/ANPTGHT-Silicone-High-temperature-Brewing-Transfer/dp/B08Z3VM63K/ref=sr_1_2_sspa?crid=2TDHS7SVMMZW7&keywords=anptght%2Bsilicone%2Btubing&qid=1701707174&sprefix=anptght%2Bsili%2Caps%2C144&sr=8-2-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&th=1

    - 2''x 2mm clear plastic tubing (4 pc, each 16.5 in length) **$21**

https://www.amazon.com/gp/product/B0925FF2K3/ref=ewc_pr_img_1?smid=A7RV4IY8BO3K1&psc=1

December

- Order placed:
    - Burning Laser
- Wood addition to structure
    - Wall to increase height of structure
- Working with following steps while waiting for materials
- Eyeball painted:

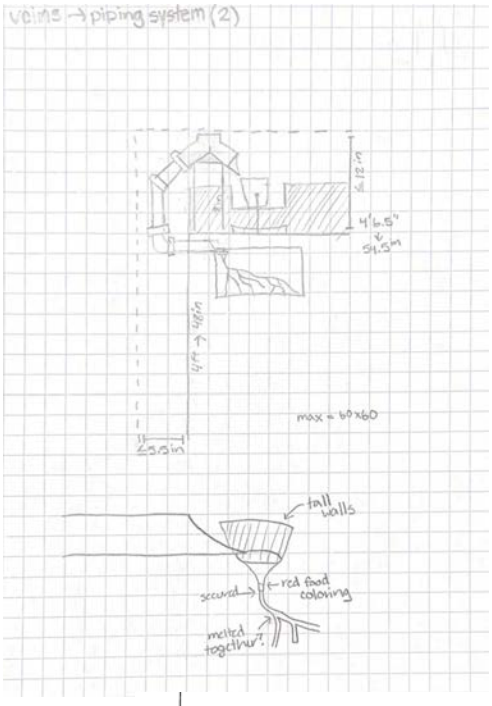
- Start of project podium started:

Process (continued)

January

- 3mm x 5mm clear tubing arrived
    - The tubing is too small
        - Water does not flow easily
- 12mm x 14mm clear tubing ordered
- Window created for vein step:

- New sketch created (on right)



Kinsey's Step (with help from Drew):

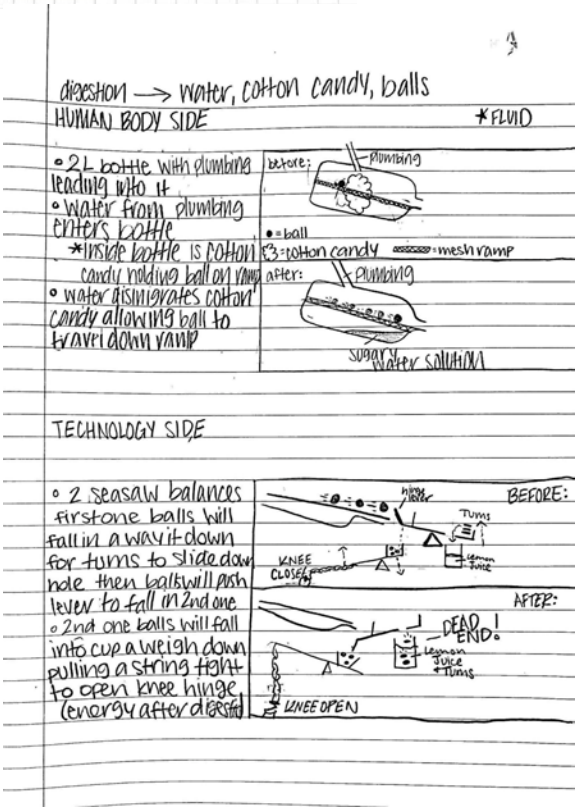
Process

November

- I drew an initial sketch of my plan for my steps
- An order was placed:
    - Cotton candy machine

December

- Ran up town to get some more supplies
    - Tums
    - Lemon Juice
    - Clear Plexi Glass Cups
- I started constructing my Technology side step
    - I created two teeter totter ramps
        - so my balls fall into a cup it weighs down the one side allowing my tums (neutral base) to fall into the lemon juice (stomach acid)
    - Once I got my ramps made I already ended up adding a marble maze to drop my balls into the teeter-totter.
        - By adding the marble maze it represents the food traveling through the digestive system
    - When the balls fall into the teeter-totter it makes one side lift higher allowing the tums to fall through a hole where a cup of lemon juice is set.



Early January

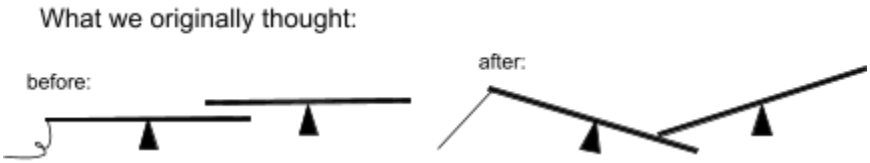
- Started doing trials
    - After trialing the lemon juice with Tums, I discovered that the Tums take too long to fully dissolve in the lemon juice, so it wasn't showing the reaction in time.
    - I then tested mashing the tums up into a powder to get it in smaller pieces, which also did not work as I planned. The powder just sat on top of the liquid and would not mix in, it was creating a film.
    - I then tested sodium magnesium crystals, which dissolved quicker but not quick enough.
    - Lastly I tried dissolving tums in water and starting with the base in a liquid form which instantly turned my solution to a neutral which is what I wanted. The only problem is now I have to reconstruct or modify my teeter totter to be able to transfer a liquid into a liquid.
        - I used ½ cup of distilled water and put 3 calcium carbonate tablets in to dissolve, after 15 min the tums had only halfway dissolved, but dissolved enough to give me a lower pH base level.
        - Another major predicament is whether I should find a way for this step to still work with a solid going into a liquid because that is how humans ingest, rather than a liquid.

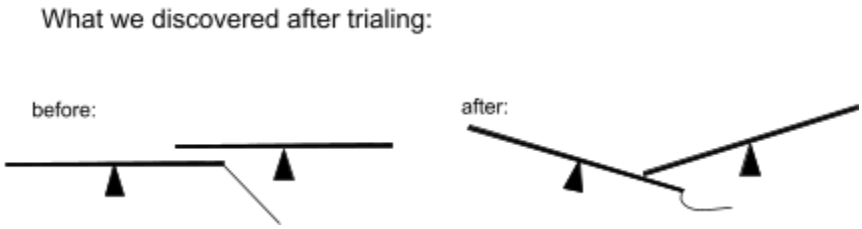
Still testing and trialing….
Most recent acid (pink) to base (yellow) change with water and dissolve Tums solution, into a water and lemon juice solution.

- Drew and I have been trying many different combinations to get the reaction we want.

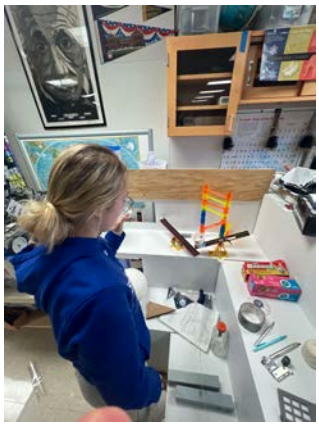
- Still waiting on the cotton candy machine, to start trials

While trialing, Hannah and I have tried to test our steps together to open her knee.





We thought we needed to get the string pulled tight but after trialing it didn't open the knee it tipped it over. So we tried moving the knee forward or backward and the result still wasn't what we wanted. The more we thought we decided we needed to start with a tight string and get it to loosen to drop open the knee. We measured so the string started tight and when we let go it pulled my teeter totter down on its own, so we placed weights on the left side to keep it balanced. This is what we have been successful with and are still tweaking it to get our final decision.

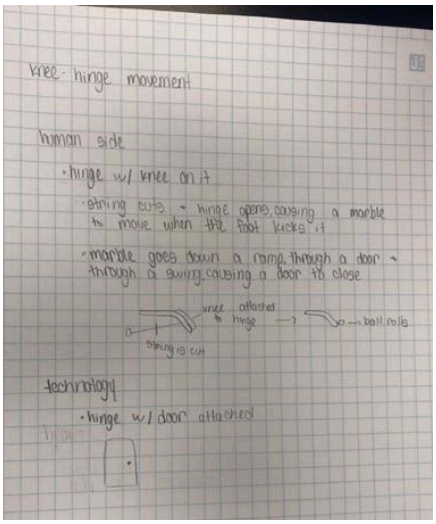


This is me trialing my marble maze into my teeter-totters. This has been working quite well but might have to change due to my acid and base step and what I get to work.

Hannah's steps

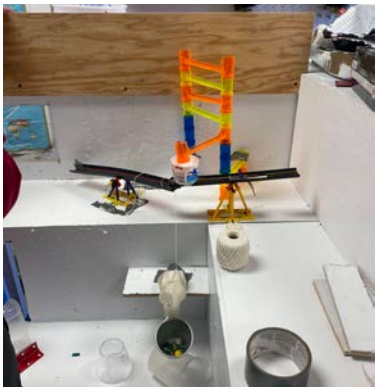
Process

- Drawing out how the
- step will work →



December

- 3-D printed a knee and door
    - Cut the knee in half and attached a hinge to it to represent the movement the knee does, along with attaching a cup to lead into my next step.



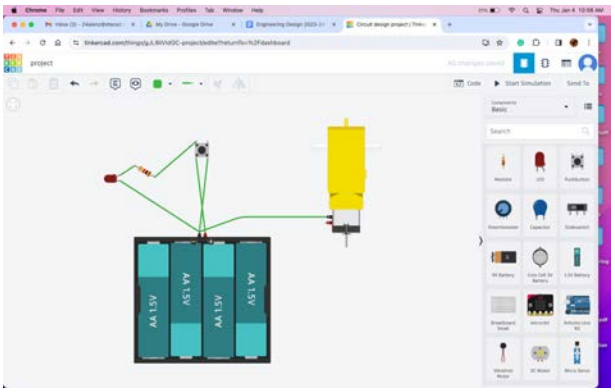
January

- Temporarily attached my first step (the knee part) to the project to see how it would work
- Tried different techniques and began to play around with how to best get my step to work
    - Figured out we need weight on the other side of the balance to even out the weight so that the balance can hold the knee in place until the marbles drop into the cup

Alex's Steps:

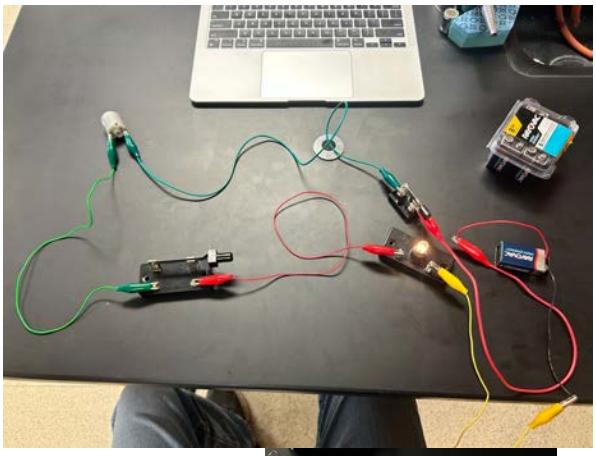
My initial plan for the electric step→

- I used tinker cad to design a plan that would turn a motor once a button was activated



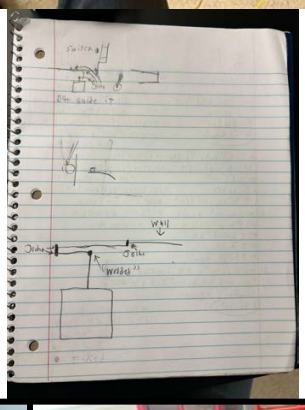
I went through multiple iterations of the step, making it more reliable each time, this ended up being my final design →

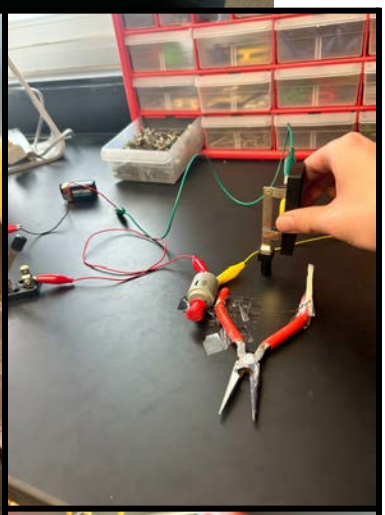
- One switch will be open and one will be closed. Once the toy hits the switch closing the system, the Motor, and light will turn on. The motor will turn a “wall” which then once it releases the pendulum and gets low enough hits a switch that opens the system. This turns off the motor and light.

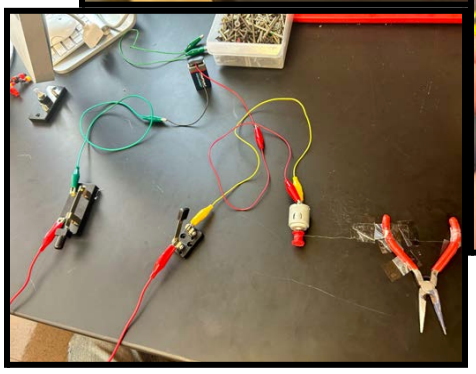


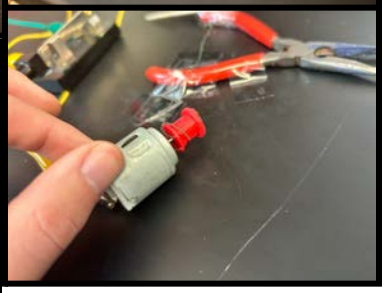
This is my initial design to release the pendulum→

- There are a few problems I see with this design.
    - The first major flaw is how durable the materials would have to be For it to work
        - After some consideration I decided to go with a simpler design that maybe isn't as reusable but is much simpler. Instead of using the motor to move a wall, I will use scissors which would cut the line.
    - The other problem is the amount of force that would be required to turn it and if it would be too much for the motor.





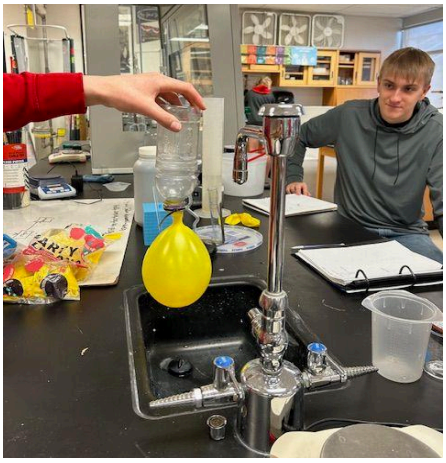


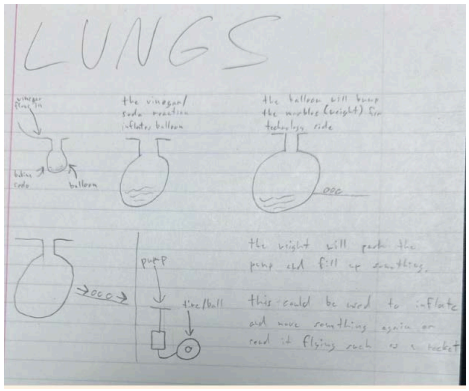


Refined Design:
For safety and testing I was using Pliers instead of scissors. In this new design, I had a winch-type of design that would pull the “pliers” closed, This would cut the string.

As you can see in the picture I planned to use a switch and a pair of scissors to shut off the motor. As the motor closes it will open the switch which will shut off the motor so it doesn't burn out and save on batteries. I'm using a toy with some parts that I had designed and 3D printed to work on the toy. I chose this design as I needed a spacer between the "ram" and the base of the toy. If I didn't there wouldn't have been enough room. In the final picture in the bottom left I experimented with closing the pliers. I found out that wrapping one part of the string around the output shaft of the motor was the best option and seemed to close the scissors while still providing much-needed torque.

Lungs → Pressure Rocket

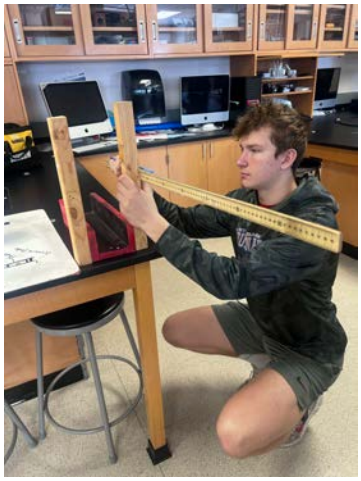




Mouth:







ORDER

1. Veins (body) involves water
    - Start → pour water into bottle
    - Small piping fills
    - DEAD END

   Veins (mechanical)
    - Start→ water poured into bottle goes into piping
    - Piping looks like plumbing
    - End→ water flows into next step
2. Chewing (body)
    - Start→ Water fills up a cup
    - Cup tips over

- End → water flows into next step

~~3. Chewing (mechanical)~~
- ~~Start → water flows into a "path"~~
- ~~(pliers included)~~
- ~~End → water lands in cotton candy~~

4. Digestive (body)
   - Start→ water lands in cotton candy (holding balls)
   - Cotton candy dissolves
   - End→ balls fall and trigger next step

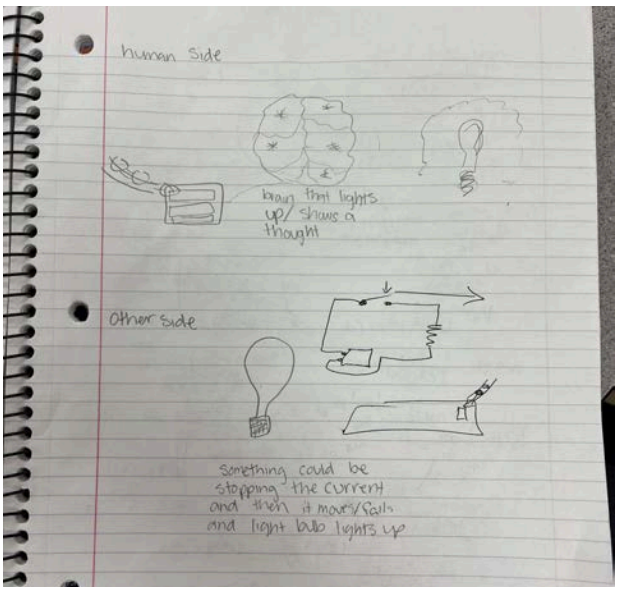
~~5. Digestive (mechanical)~~
- ~~Start → balls travel to a balance~~
- ~~Balance tips, causing tums to fall into lemon juice~~
- ~~End → A few balls fall into a cup~~

6. Knee (body)
   - Start→ balls weigh down cup
   - End→ pulls a string tight
7. Knee (mechanical)
   - Start→ marbles release
   - End→ marbles push a door open
8. Lungs (body) chemical reaction
   - Start→ bottle gets knocked over by door
   - Balloon fills up
   - End → filled balloon pushes something
9. Lungs (mechanical)fluid step
   - **Start→?**
   - Pressure rocket
   - End → rocket hits something
10. Running (body)
    - Start → rocket hits small plastic toy
    - Plastic toy goes down ramp
    - End→ motion sensor (or switch)
11. Running (mechanical) electrical step
    - Start→ motion sensor (or switch) turns on light
    - End→ Electrically, next step is triggered
12. Eyes (body)
    - Start → electrically, the pendulum is set into motion
    - Pendulum hits an "eye" ball
    - End→ eyeball rolls and triggers next step
13. Eyes (mechanical)
    - Start→ eyeball causes the button to be pushed on laser
    - Laser goes through magnifier (mostly for effect)
    - End→ laser breaks balloon which is holding marbles
14. Vocal Chords (body)
    - Start→ Marbles drop

- Marble falls into PVC maze
- Marble makes sounds
- End→ Marble falls onto next step

15. Vocal Chords (mechanical)
    - Start→ marble lands on the play button of speaker
    - Speaker plays something
    - End→ marble keeps rolling
16. Brain (body/ mechanical)
    - Start→ marble lands on battery which turns on lights
    - Brain lights up
    - End→**?** marble rolls to turn the light bulb on

- Compare human components and mechanical components… how can we advance technology?
    - What the human body does on the inside affects what we see in technological advances on the outside



Melissa Huppert, PhD
Program Director

Contact
507-508-2987 (c)
Engineering.mnsu.edu/EMDC/
Melissa.huppert@mnsu.edu

February 8, 2024

Dear EMDC Teams,

We are excited about your participation in the Engineering Machine Design Contest (EMDC) and your enthusiasm for incorporating the EMDC identity into your projects. To support your creative efforts, we hereby grant you permission to use the EMDC logo, theme graphics, and program level sponsor logos in your machine design, without alteration. This letter does not provide permission for use of regional contest or team sponsor logos. Permission for use of those and other logos must be obtained if they are used.

Please ensure that any use of these graphics or logos adheres to our guidelines, maintaining the integrity and spirit of the EMDC. Should you decide to include any of these elements in your design, it is mandatory to print this letter and have it available for review by the judges during the contest, if requested.

We believe that incorporating these elements can not only enhance your design but also foster a sense of community and shared identity among all participants. However, there is no scored advantage for using these elements. We look forward to seeing your innovative designs and wish you the best in the competition.

Sincerely,

Melissa Huppert

Melissa Huppert