BioCoug Innovators
Sumner-Fredericksburg Team 2

Team Members:

Chloe Bolte
Isabel Christensen
Maya Collazo
Caden Trainor

Ty VanEngelenburg
Davis VanSickle
Kallen Wilharm
Jaxon Willems

Contest Theme:
Human to Tech Transfer
Advancing Technology by Reverse Engineering the Body

Team Theme/Name:
BioCoug Innovators

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Overview

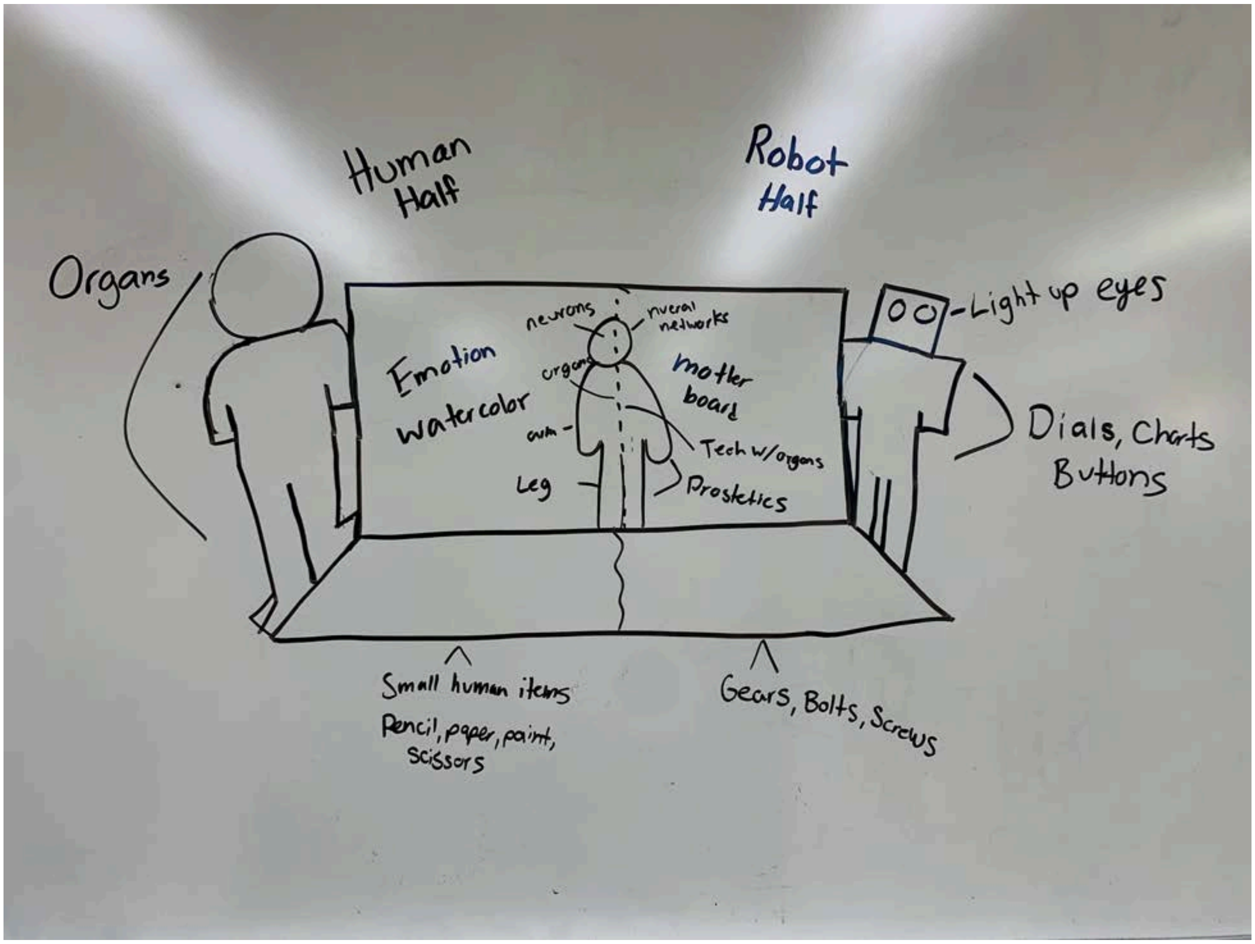
Design Team	Building Team	Decorating Team
Chloe Bolte	Kallen Wiharm	Isabel Christensen
Jaxon Willems	Jaxon Willems	Chloe Bolte
Maya Collazo	Ty VanEnglenburg	Maya Collazo
Caden Trainor	Davis VanSickle	

Total Number of Steps:
17

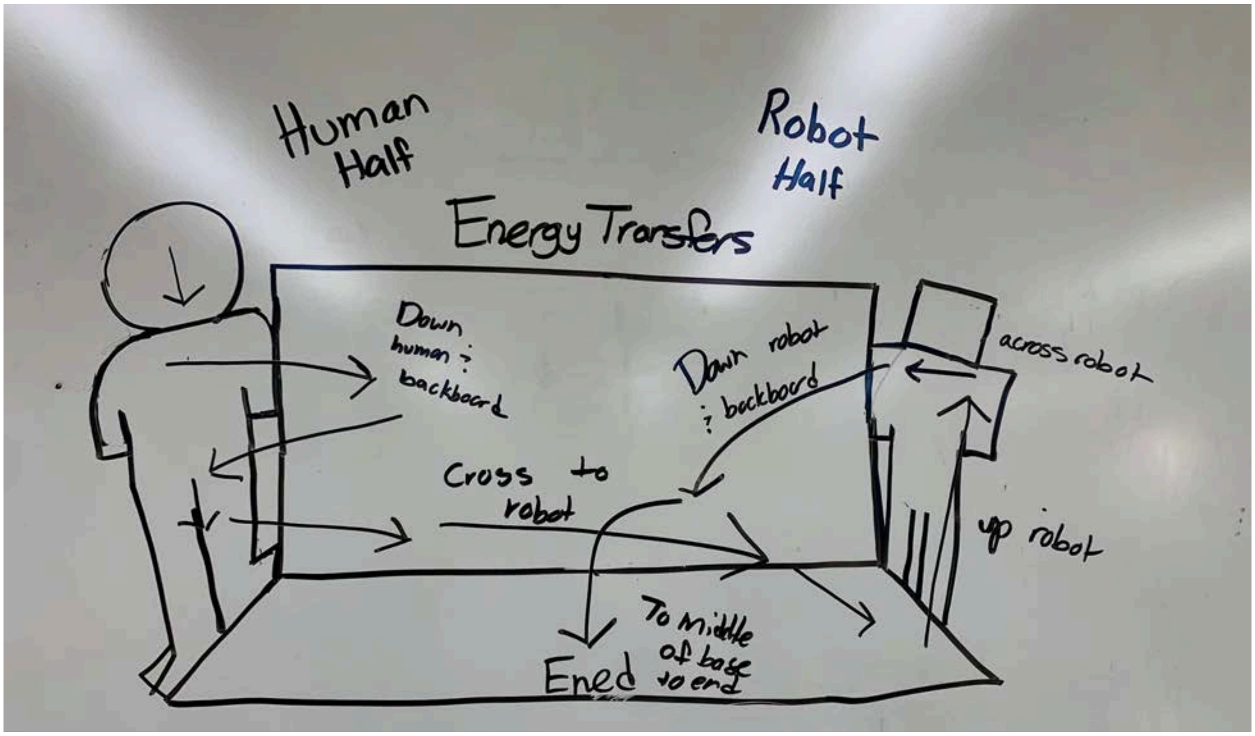
Our End Goal:
Lift a banner celebrating the completion of our rube and the impact technology has had on our lives and how it makes life easier.

1.Planned Machine Design Sketch and Description

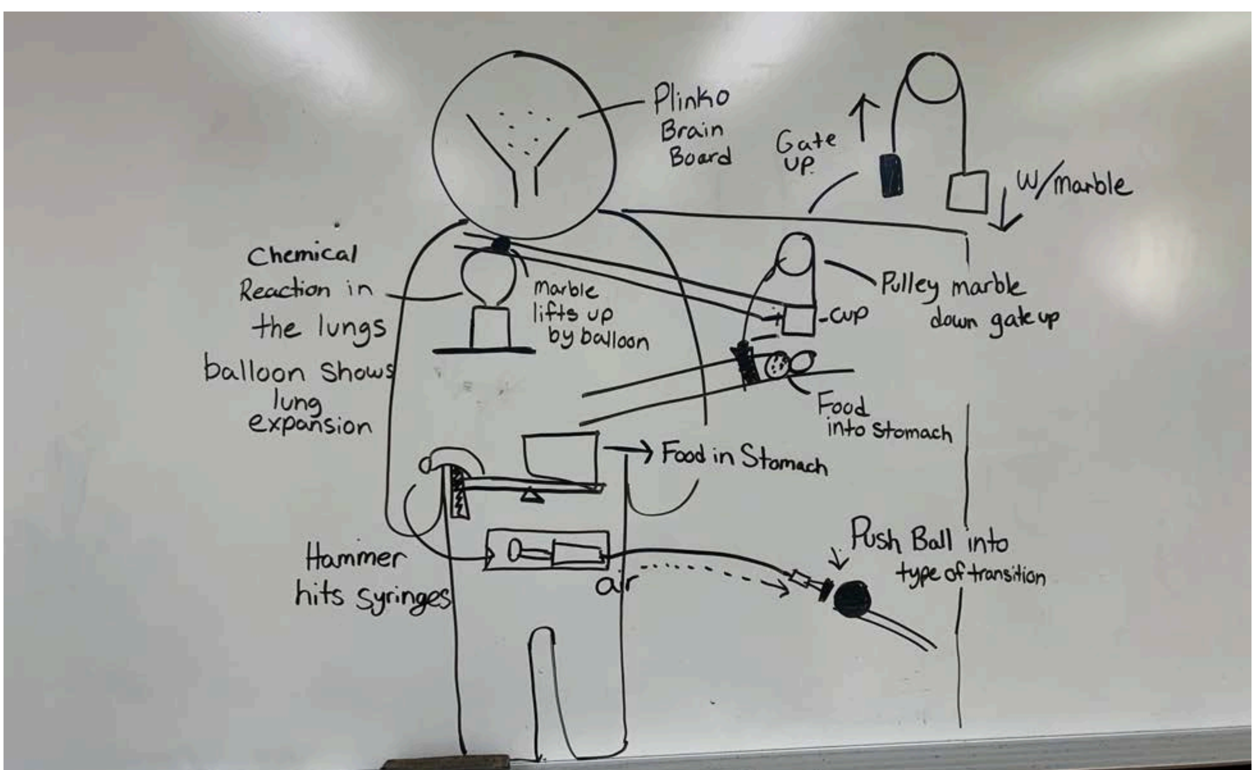
Design Sketches



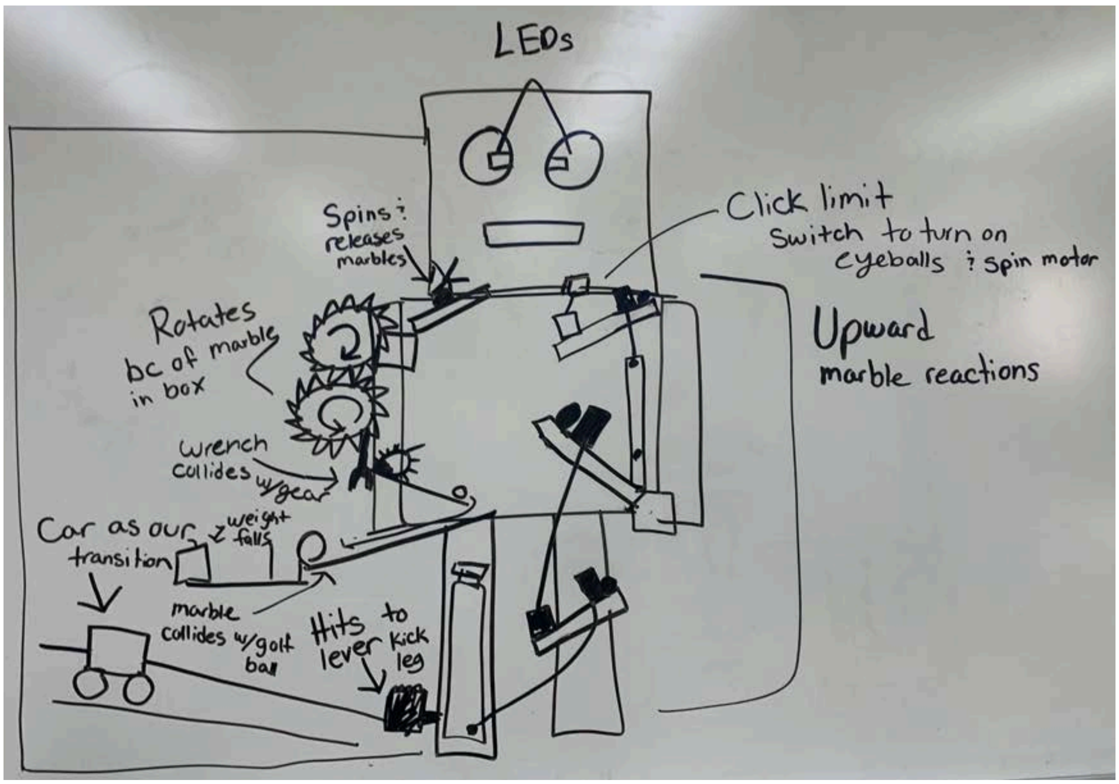
Here was our initial art plan headed into Christmas break. Our plan was to complete all of the background art and build the structure during break. We really wanted our art to reflect the theme. We have two separate halves: the human and the robot. For our human side, we want to paint organs on a black background, so we can tie steps to organ functions. Maya came up with the idea of watercolor splatter emotions on the backboard. We felt this represented human emotions well and shows the creativity the human mind possesses. She also came up with the idea to paint small objects used in human life everyday on the base. For our robot side, we used a similar thought process. On the robot itself, we painted dials, buttons, and screens. The backboard we painted was like a motherboard: the brain of the robot. We made this very systematic and organized like the programmed robot's mind. The base on this half was painted with miscellaneous robot parts such as gears, screws, and bolts. In the middle of the backboard, we painted a person: half human and half human tech. In the brain of this human, we had neurons and neural networks (AI's processing mechanism that mimics neurons). Then, we have half organs and half gears mixed with organs. On the legs we have normal human limbs and prosthetics.



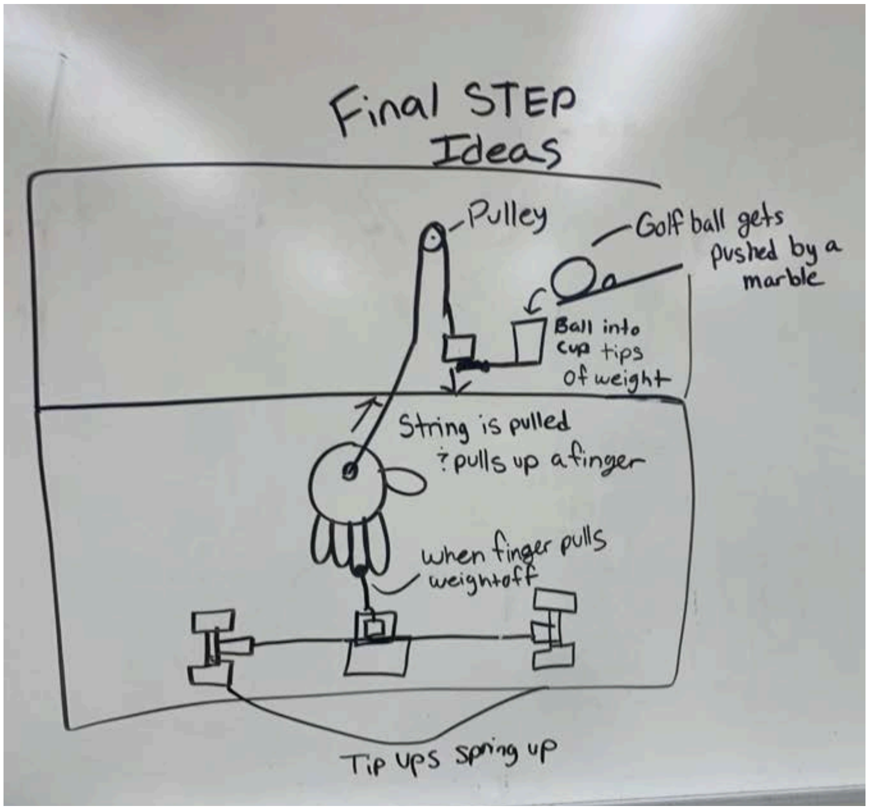
Here is our sketch of our energy transfers. We want to work down the human half using both the human body and the backboard to attach steps; then, we want to transfer the energy to the robot side. Here the boys want to create a reaction to bring energy back up the robot. This allows us to use gravity again to work back down. Then, they will work across the robot and backboard to get the energy down for our final step. We are planning on ending our rube on the base board.



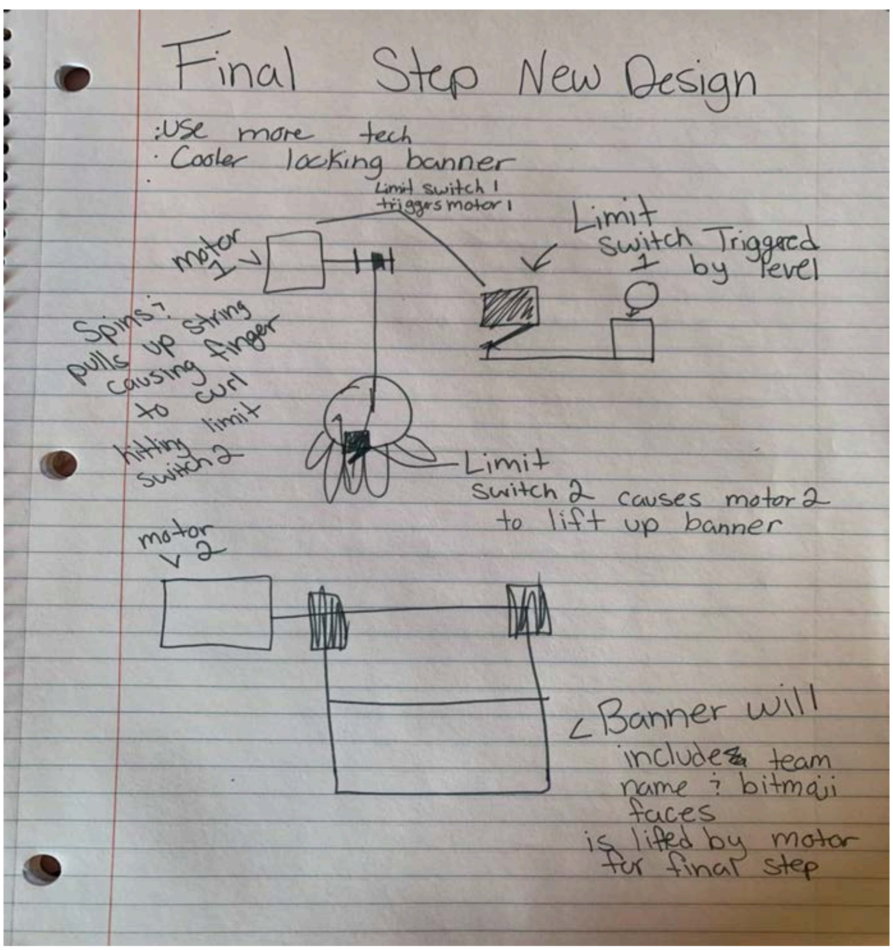
Our human side will begin with a team member dropping marbles in our brain. From there, the marbles will fall into a cup hooked to a pulley. This will lift up a balloon filled with vinegar and dump into a bottle of baking soda. The mixture creates carbon dioxide gas and blows up a balloon. The balloon will lift a lever and send a marble down a track. From here it will fall into a cup and lift up a gate, releasing food into our stomach. When the food lands in the stomach, it throws off the balance of a lever and tips off a hammer. The hammer hits a syringe and pushes air through tubing and to another syringe. This syringes plunger extends and pushes a large metal ball to start the transition to our technology side.



Our robot half will start when a car collides with a lever, forcing the leg to kick. This leg is tied to a block holding back a marble. The marble will be released, and it will collide with another block. This block will pull down the block above, releasing another marble. This marble will collide with a lever that forces another block to fall and the last marble to be released. The final marble collides with the final block; when this falls, it clicks the limit switch. The boys found this step chain and wanted to find a way to incorporate it into our design. Once the limit switch is pressed, it will cause the eyeballs to light up and will spin a motor releasing a ball. This ball will fall into a box on a gear, spinning it clockwise. It will mesh with the gear below causing it to spin counterclockwise, where a wrench will push a gear down a ramp. The gear will collide with a marble, sending it down a ramp; then, it will collide with a golf ball, knocking it into a cup on a lever. The ball throws off the balance of the lever, knocking off a weight. This weight will pull a string and curl up our mechanical hand in our final step.



Originally, for our final step as mentioned, when the weight falls, it lifts up on a string. This string pulls through a finger and makes it curl up. The finger is connected to a mass that holds down our tip-up flags. When the finger curls up, it pulls the mass off of the flags, and they spring up showing our flags in celebration.

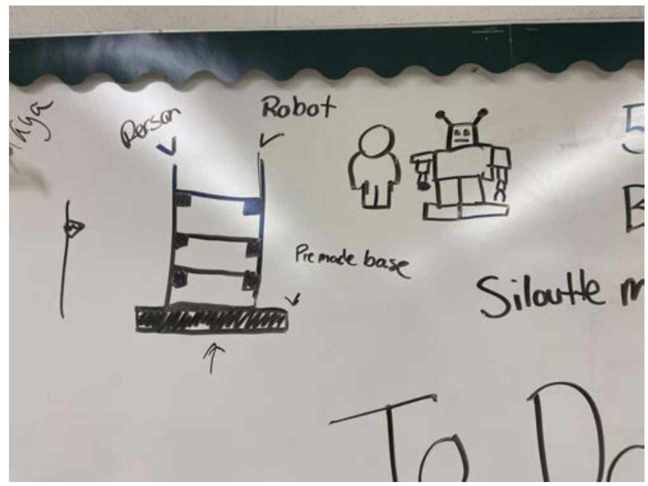


After our first competition, we wanted to make our last step more of a wow factor. Maya came up with a new design that would use some more technology and really show the transfer. Our lever that pushed off the weight now will hit a limit switch. This first switch will spin a motor to curl up the fingers of the hand. The finger will curl and hit a second limit switch. The switch will lift up our banner. The banner will have a fun Cricket cut design and our team name on it.

Daily Logs: Week One

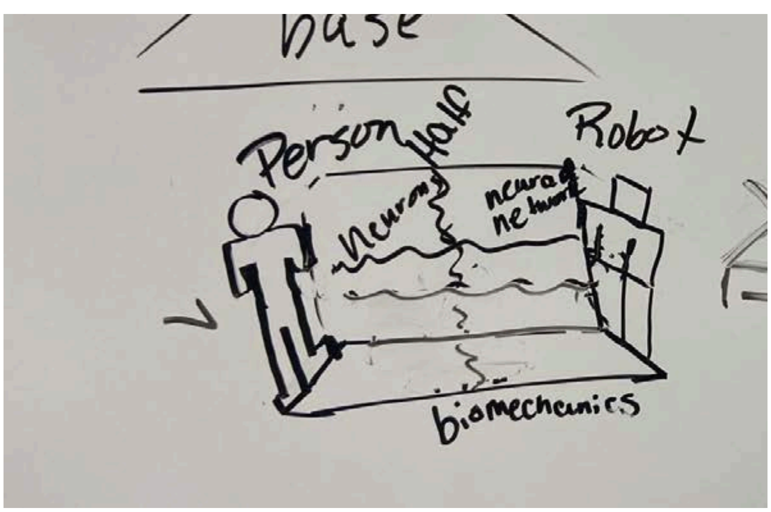
12/14

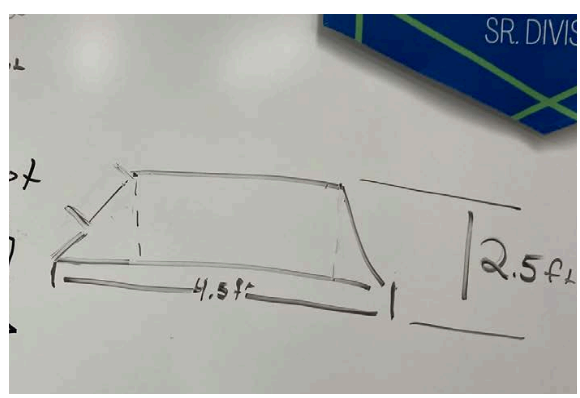
Today was our first official day of getting to work with our groups. We mainly focused on what our design plan would look like, what materials we would need, and brainstorming measurements. ***We came up with an idea to have two boards facing opposite each other with shelves in between with the idea of having a human side and a robot side.*** We thought this went well with the Human to Tech Transfer theme. We mainly got our supplies today and created designs on the whiteboard. **Shown to the right is our original design. After discussing it we found too many issues. It would be very hard to space and create smooth transitions.**



12/15

As we thought more about what design we wanted and what would work, we thought that our original idea would be too hard to link steps. Our design and building team came up with a new idea, along with measurements and dimensions. Our new design would look similar to a trifold board: human on the left, mix in between, and robot on the right. This would allow us more space to work and a more inviting design. Compared to our original design, the logistics of this made much more sense and would be easier to build on. **Below is our initial second design: our plan is to work down the human side, across the base board, back up the robot, and finally back down the baseboard ending in the middle of the base. We wanted to make the width about 30" so it would fit through any door.**





12/18
During class today, we determined the measurements that we wanted to use for our robot silhouette to stay within our five-foot dimensions. Kallen and Jaxon worked on getting the wood and cutting it. We also came up with a better design and sketched it out on how we wanted to do our artwork. Chloe sketched out the human silhouette on the wooden pieces, and the boys took care of cutting it out. When dimensioning out the human, Chloe made sure it was proportional: she measured her legs and torso and used that ratio.

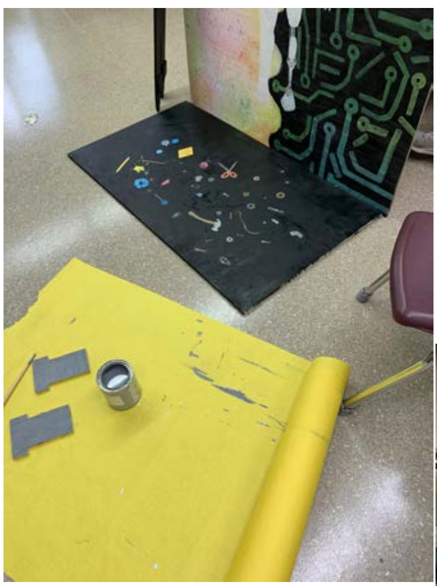
Daily Logs: Week Two

12/20
The boys got our wood cut out in the shop today for our "human side". This board will have the concept of the human body with organs painted on them. We girls painted a couple of black coats onto the body and got the brain sketched out on the head. Both the wood and paint supplies were repurposed from past projects at our school.

12/21
This morning Chloe got started on cutting paper in the shape of the organs we wanted, that way we could trace the organs onto our board, which would be easier for us to paint. ***Chloe and Isabel got started on painting the organs today.*** The paint supplies were repurposed from past projects at our school.

Christmas Break

Over Christmas break, we got to work on getting our project built. Our baseboard was brought in by Kallen, and the boys cut it to fit inside our required dimensions. Maya bought our board/background from Menards for one dollar. It will be placed in between our two bodies. Chloe got the robot's limbs cut and painted. The girls took home the base, backboard, and robot to paint. We painted the robot's body, baseboard, and backboard.



The day before school started after break, we met at the school to get all the parts screwed into the correct places. When creating our design, we made sure it was 30 inches wide. This gives us the ability to fit it through any doorway without disassembling. We were very excited to see our planned design come to life!

Daily Logs: Week Three

1-5

Since we have our rube structure built, we started working on the steps. We decided that the girls were going to work on the human side of the rube with the chemical step and fluid power step. The boys are doing one of the mechanical steps and electrical step. They are planning on incorporating various levers and inclined planes. For the electrical step, they are trying to turn on the robot's eyes and trigger a motor to release the next step. The girls' steps will work down the human side and create the transfer between the sides. The boys will work back up the robot body using inclined planes and marbles; then, having potential energy on their side will work back down to the finish.

The girls got started brainstorming on what type of step they wanted to start with. They wanted to start with the brain because that is where the functions in the body start. We decided on using a Plinko Board with marbles going down. The marbles would represent neurons in the brain going around and down to the spinal cord.

1-6

We got started right away on painting and cutting the wood. We first painted the dowels, and Jaxon helped us cut them. We also painted a block of wood for the perimeter. Chloe and Maya worked on cutting the wood and gluing it onto the brain. This is to create our Plinko board brain.

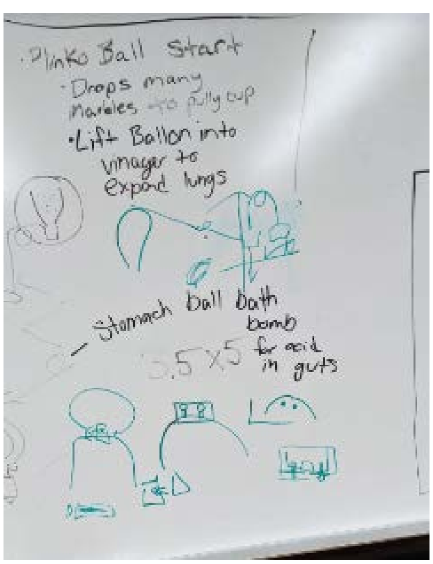
Daily Logs: Week Four

1-8

Everyone split into little groups to start brainstorming and work on building their steps. Caden got to work on looking up how he is going to do the electrical step. He plans to start some type of motor and also light the robot's eyes. Jaxon and Kallen got to work on making a small-scale model of how to make their mechanical step. When researching step ideas, they discovered a video of an upward chain reaction. It involves marbles being held up with blocks and the blocks being pulled from under, releasing the marble above. This step allows us to get back to the top of the rube and start using gravity again. Jaxon and Ty got to work on steps that would be in between the electrical and Jaxons and Kallen's mechanical steps. They decided to have the final block pull on the limit switch to trigger the eyes.

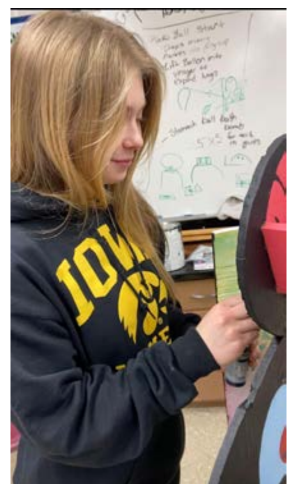
1-10

We had a snow day, and the girls came in to work on the steps on the human side. They created a platform for the chemical step and also set up the pulley. They also reattached the head with a metal plate instead of wood due to the wood stripping with constant removal.



1-11

We split back up into our groups and got to work on our steps. We girls got to work on cutting the plexi glass and painting the back of the head black, so it would blend in with the rest of our painting. We also got a ramp cut out for the marble that drops out of the brain. Kallen and Jaxon started working on their full-size model for their mechanical step. Davis and Ty are working to create a step using gears. Their plan is to create a marble catch, so when the marble lands in the catch, it turns the gears. Caden is working on an electrical step that starts with a bump of the limit switch. When the limit switch is triggered, two LEDs turn on in the eyes. Two seconds after LED'S turn on, a motor runs for another two seconds; then, everything turns off. The limit switch, motor, and LED's are connected to a VEX net brain that runs on a 7.2 volt battery. The code is programmed by ROBOTC and downloaded to the VEX net brain.



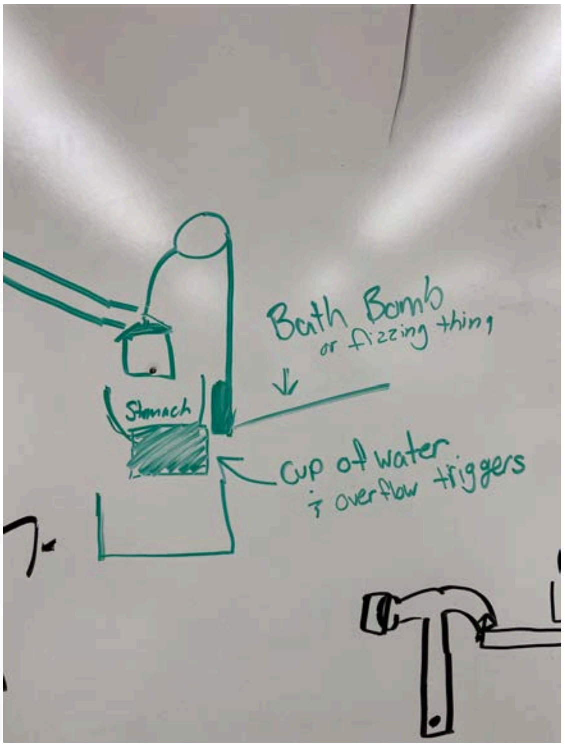
Daily Logs: Week Five

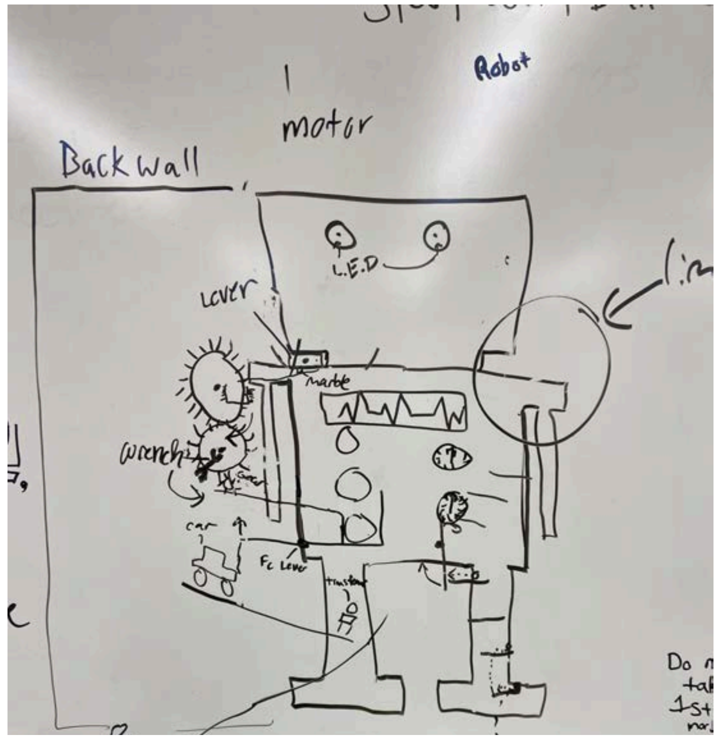
1-15

Today Maya and Chloe worked on our chemical step that included baking soda and vinegar. They put a platform of wood by the lungs to put the balloon on. The balloon is attached to a pulley and water bottle. The pulley will lift up the balloon and drop baking soda into the bottle of vinegar. The boys continued working on the electrical step.

1-16

Chloe and Maya got working on the marble ramp that will trigger the golf balls into the stomach. Caden started testing out the lights in the robot's eyes. Kallen and Jaxon started to test out their steps, along with Davis and Ty doing theirs. Chloe also sketched out how she would like to add in the bath bomb step to represent stomach acid. The boys all laid out their ideas for the robot side, so they had a clear plan.





1-17

The boys worked on their planned-out steps for the robot side. They also got working on the coded electrical step and mechanical steps. Maya and Isabel got started on getting the ramp for the marble decorated and put together. They did splatter paint on the wood to match the background. Then, we super glued the ramp onto the wood.

Daily Logs: Week Six

1-22

The girls were painting and getting the tracks looking good on the human side. The boys continued working on their steps and getting tracks drilled to the robot. Lots of painting was done today, and it made things look better. The girls painted some wooden blocks with splatter paint to help it look like the background board.

1-23

We got working on the step where a hammer will hit a syringe for our fluid power step. The boys also worked on their steps coming down the robot. Maya is working on getting cups behind the robot's eyes so the light will pop. With our fluid power step, we cut and made a hammer handle to attach to the hammer head we found in the shop. We are also trying to figure out what our end goal is. We are thinking we want to have flags swing up to celebrate our rube and the continuous impact technology has on human life. Now that we are using flags, we needed to change up our transition. We think it would be neat to make the leg kick and pull Jaxon and Kallen's first string.

1-24

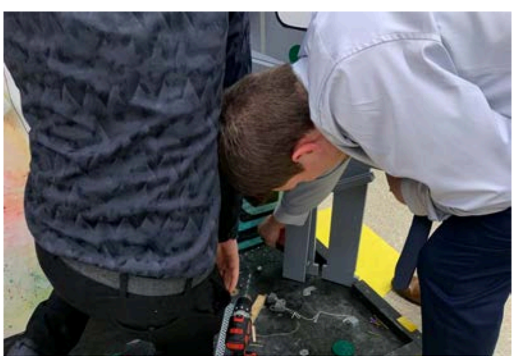
We created our prototype cardboard hand for our final step. This was so Maya had a prototype to build off of. She is planning on using wood blocks sanded to the shape of fingers with dowel and pin joints. Her goal is to have it completed over the weekend. We continued to tweak our other steps. Jaxon and Ty were working on the final steps of their side. They were also trying to figure out how to tie their side to the ending. We were also brainstorming ideas to add a step between our fluid power and transition step. Chloe watched some videos and found the idea of a spinning paddle. The paddle would be hit by a heavy metal ball, spin, then push a car down a ramp.

1-25

We got started on working on our fluid power step, which involves the syringes and tubing. The hammer that falls from the lever will hit the large syringe; then, air will be pushed through tubing and cause the small syringe's plunger to extend. The metal ball pushed by the syringe collides with a paddle. Caden started to cut these paddles out of plywood. Maya started construction of the wooden mechanical hand. We figured this would be stronger and more durable than the flexible cardboard.

1-26

Today we split up into our groups again to work on various steps. Maya continued to work on her hand for our final step. She is planning on finishing it this weekend, so we can get the ending steps ready. Kallen also worked on our last step. Kallen cut our brackets to hold down our tip-up flags. Jaxon put on our hinging robot leg to "kick off" our transition between our human and tech side. We decided to use a leg since it is a human function done by the robot. This allowed a cooler transition between our sides. Caden, Ty, and Davis are figuring out how to wrap up their side and bring it back to the middle. They built and attached another lever to continue the reactions. Chloe finished assembling our emotion paddle to get us another step.



Daily Logs: Week Seven

1-29

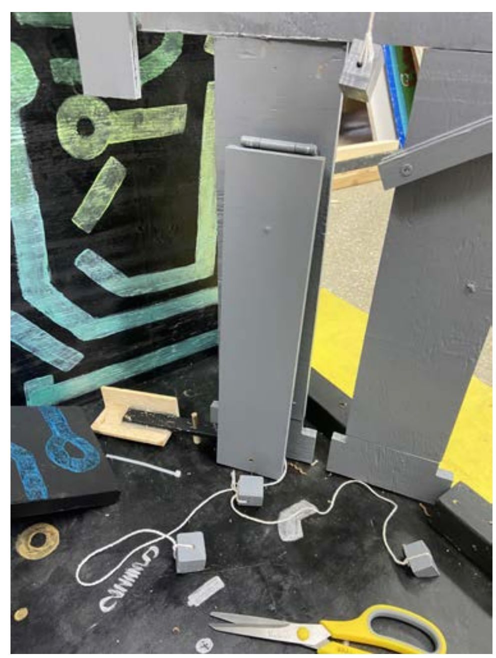
We got to work on making the ramp for the car to fall down and hit a lever. The lever then will trigger a leg to kick. Once the leg kicks, it pulls a string connected to a block that releases a marble to hit another block. This reaction continues up the other leg of the robot.

1-30

Today we mainly focused on working on the final step and the steps leading up to it. For our last step, we want a wooden hand with strings to pull the weight off of the banner. While the weight comes off the banner, the tip-ups lift up with our flags. We used old fishing tip-ups that were found in Chloe's basement. We repurposed them since they are spring loaded rods. We also started to run through the steps we already have done to make sure they run smoothly.

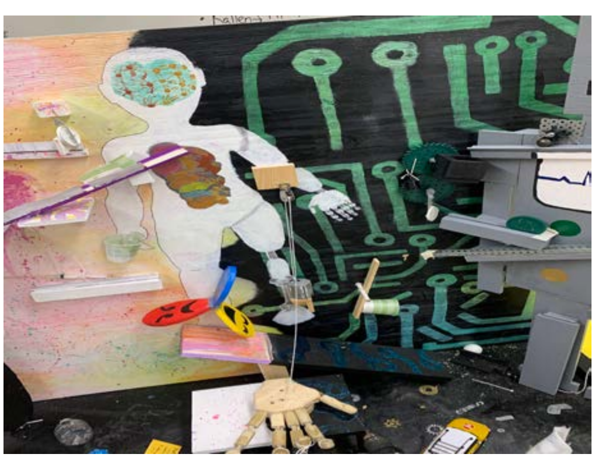
1-31

Today, we worked on fixing the spots with imperfections and mistakes that may happen. We also got started working on the presentation and our storyline.



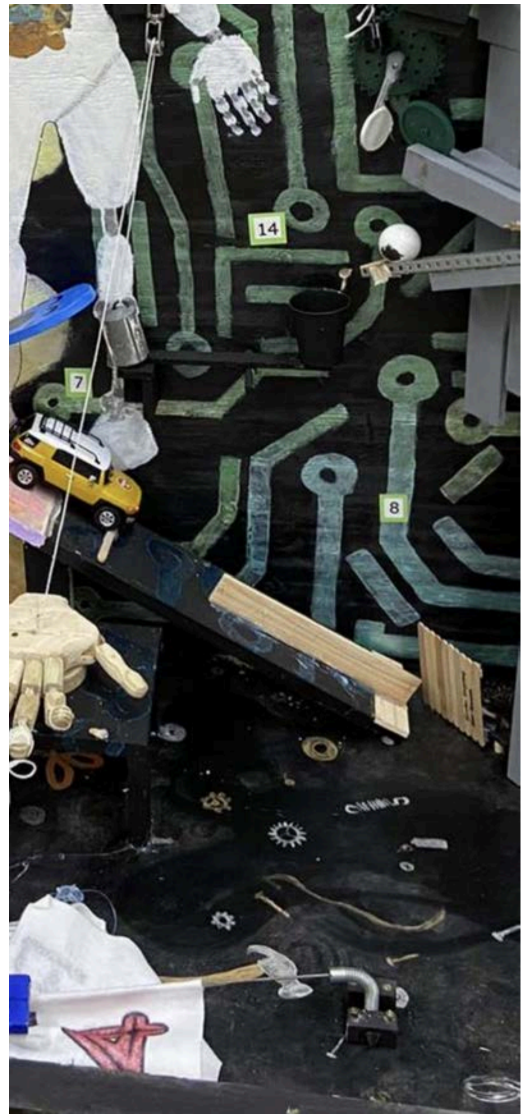
2-1

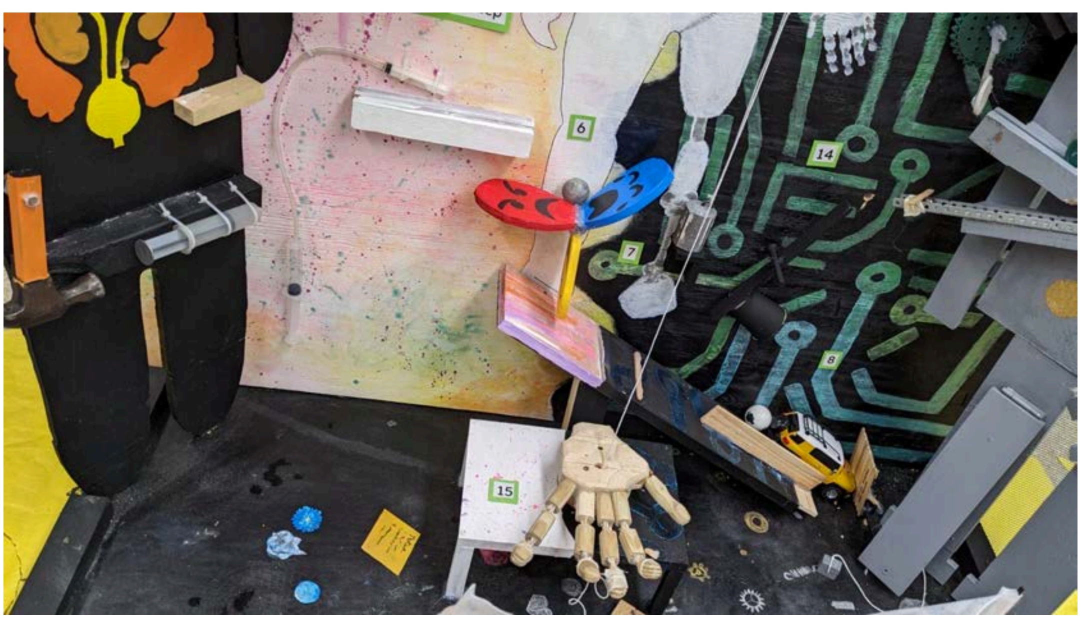
Today we completed the final steps of our rube. We were able to successfully flick a weight off a lever and cause our mechanical hand to pull our final step weight. We also continued to paint the rest of our pieces to keep our rube looking clean.



2-2

Today, we did our first full run through. We had a few touches and were able to find our issues. From that, we started to work out some of our issues and will continue to troubleshoot. One of our biggest issues was our chemical step. The balloon was not lifting up our lever. Chloe stayed after school and created a new tunnel with less friction and we will be creating balloon guides. On our third step, the gate was creating too much friction, so we are working to eliminate that. For our fluid power step, we have discovered we need to work the syringes for it to work consistently. We will also have to create a net behind the robot since the marbles from Kallen and Jaxon's marbles like to bounce out. In a few spots we need to eliminate the use of tape and work with sturdier materials. We were very pleased to see the mechanical hand and tip-up flags working.





2-28

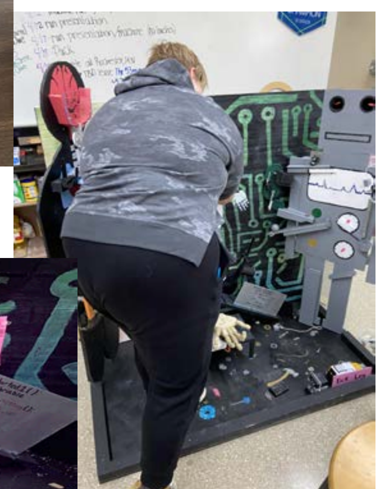
Today, we worked on our ending step. We decided that we needed to have a bigger ending, and Maya had some good ideas. Her idea involved using more limit switches and some more pieces of the Vex robotic kit. Chloe worked on painting our pseudo code to python code transition. To help tie our step with the car creating the leg to kick back to the theme.

3-5

Today, we worked on painting the esophagus and jaw. We did this to tie another one of our steps better to the theme. We wanted to use a jaw as an example of dentures, a new technology that has benefited human life. Maya worked to code our ending step.

3-18

Today, we worked on changing our ending step to make it cleaner and incorporate some more technology. Maya screwed in the motor and its bracket into the base. Chloe finished creating the new banner and its frame. Over the weekend, she used her Silhouette to cut out our bitmoji faces and our team name.

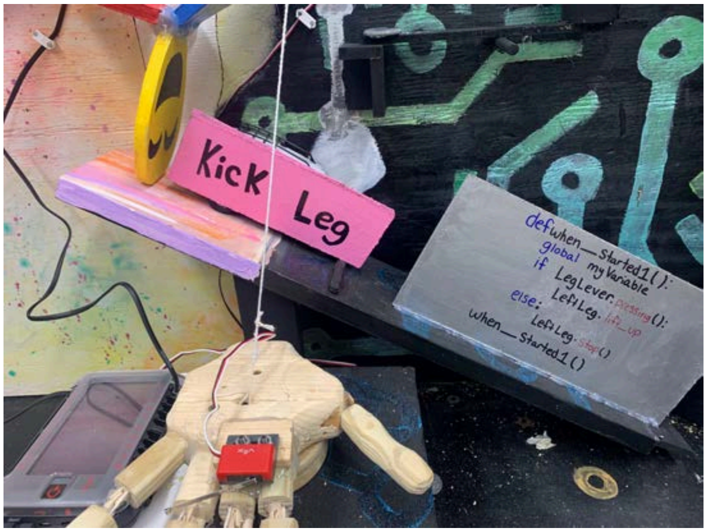


3-25

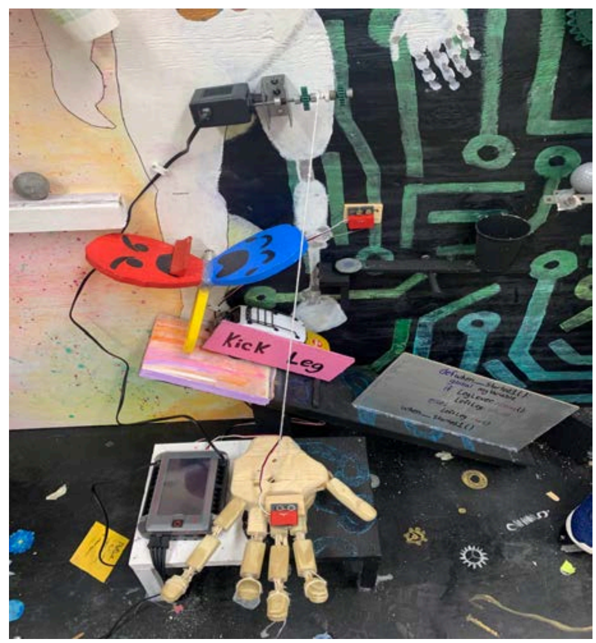
Today, we worked on improving our steps and making sure everything was working properly. The boys cut a piece of wood to help hold our banner straight. Maya also created a piece to hold up the axle that lifts our banner. She did this so the axle did not bend and had some support on the side. Jaxon and Kallen changed their upward marble reaction, so it is more consistent. They decided to flatten out the incline planes; this allows the blocks to sit better on them and slip off less. Jaxon also started cutting our prosthetic leg so we could attach a PVC pipe. Our plans are to attach a ball to then end of the leg and then add a baby shoe

4-1

Chloe and Maya put all of the mechanical pieces on the board. They also tested the coding to make sure it works. They also finished updating our prosthetic leg, they added a foam ball and the baby shoe. We have finished all of the major changes and we are now on to the slight tweaks to increase our machines consistency. Below are pictures of our major changes after the first competition.



To the left is where we tied our car step better into the theme. We have human thoughts represented as pseudocode turning into python coding so the robot could understand.

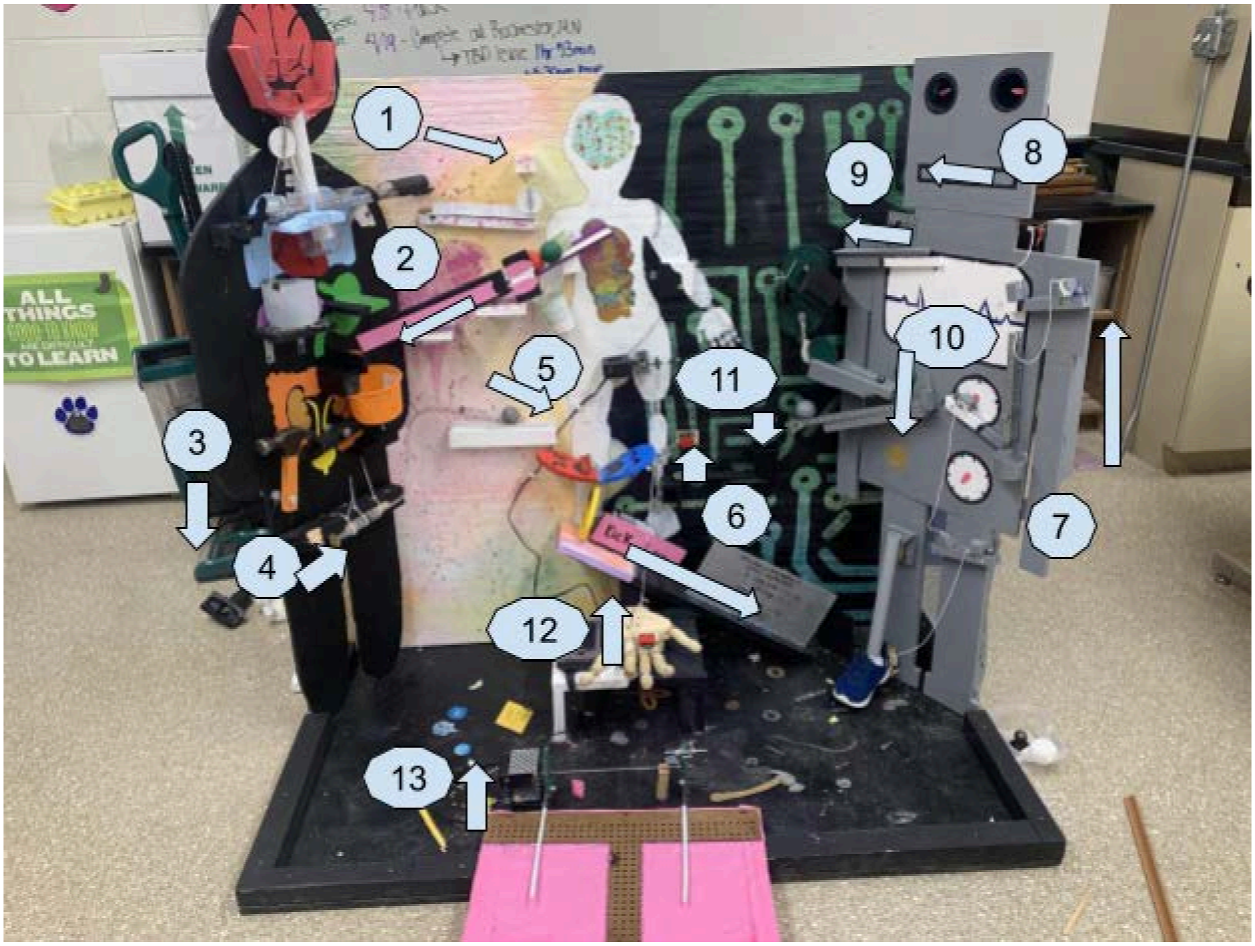


To the right shows the mechanical pieces we have added to our final steps. We added a limit switch after our lever, that switch turns the motor. The motor causes the finger to curl hitting the second limit switch. This limit switch causes our other motor to spin and lift our banner.

The banner is shown below.

To the left is our updated prosthetic leg. We added a PVC pipe with a styrofoam ball and a baby shoe.

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



The numbers on the picture above represent major direction changes of the energy transfers. The numbers are accompanied by arrows to show the direction of energy flow.

Below, the numbers and descriptions tie to the corresponding energy transfers from the picture above. We have also labeled what steps these major transfers apply to.

The picture above shows our near final design picture. We plan to add a computer read quote. We feel the quote reflects our rube very well.

1. Our first energy transfer involves dropping marbles from the brain into a pulley. The pulley lifts up our balloon full of baking soda. **(Step 1 Advanced Component Chemical Step)** The balloon lifts up a lever; this sends a marble down the plastic tube and to the track on the back board. **(Step 2)**
    a. In this section, the energy transfer runs across our rube. This saves us room along the human body for other steps.
    b. In this section we used various pieces of scrap wood and plastic to create a Plinko board in the brain and the lever to follow. We also got a piece of plexiglass from the scraps at a local business.
2. Section two shows our energy transfer back into the body. The rolling marble from the past lever falls into a cup. This cup is connected to another pulley and lifts a gate releasing two golf balls into a cup on a lever. **(Step 3)**
    a. Here the energy transfer returned to the human body from the back board.
    b. We used pulleys, paper cups, recycled plastic, and a hot wheels track in this section.
3. The lever weighted down by the golf balls tips off our swinging hammer. **(Step 4)**
    a. Here our energy transfers 180 degrees. This allows us to work our way to the backboard where we have plenty of room to continue our reactions.
    b. In this spot, we made a hammer handle and pounded it into the hammer head we found in the shop.
4. Here our hammer hits our syringe, starting our fluid power step. The hammer hits the large syringe. Air goes through the tubing and to a smaller syringe that moves and pushes off a metal ball. **(Step 5 Advanced Component Fluid Power)**
    a. Because we used tubing and syringes, we were able to be very flexible and cover a lot of ground. We were able to transfer energy from the legs of our human back to the backboard.
    b. Here we used a 10cc syringe, tubing, and a second 10cc syringe. This allows movement on one syringe to be transferred to another syringe. We utilized Pascal's Law in this step.
5. The ball is pushed by the plunger of the syringe; it falls on to our paddle of emotions, which rotates. **(Step 6)**
    a. Our transfer of energy continues across the board; then, it turns into rotational movement ready to trigger another step.
    b. We created a spinning paddle from leftover wood and a dowel.
6. The rotating paddle hits a car. **(Step 7)** It is pushed into a lever connected to the leg of our robot. The leg pulls away a block holding back a marble. **(Step 8)**
    a. In this area the motion moves from the center of the board all the way to the robot. Once the robot kicks, the energy starts to transfer up.

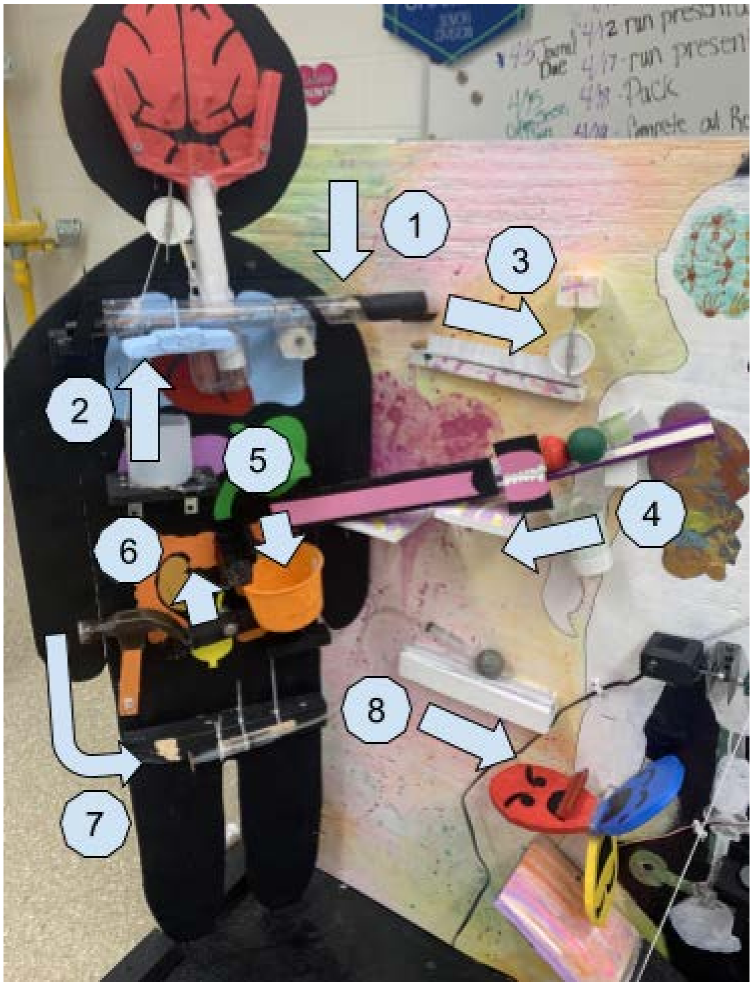
   b. We used a toy car and popsicle sticks to create the direct transfer. Around that we used many pieces of scrap wood; those were used for the following: ramp, ramp guides, ramp extender, lever, leg, and blocks.

7. When the leg pulls the block, it releases the marbles. That marble collides with another block. The second block holds back another marble. When this marble is released, it collides with the lever. The lever pulls a third block, which releases a third marble. It hits the final block and triggers the limit switch. **(Steps 9 & 10)**
   a. Our energy transfer here defies gravity. We wanted to work bottom to top. This allowed us to start using gravity and potential energy again, making the steps easier.
   b. We used very inclined planes, blocks, and marbles here. The block and inclined planes were made of scrap wood, which we cut custom to fit our needs.
8. When the limit switch is triggered, it causes the eyes of the robot to turn on and a motor to spin. **(Steps 10 & 11 Advanced Component Electrical Step)**
   a. The energy here goes across the robots shoulders.
   b. We used VEX Robotics pieces and string to pull off this transfer. We used Robot C coding language. Caden also used an infinite loop so the code would run constantly and we would not have to re-download to the computer every time we ran the code.
9. The motor, triggered by the limit switch, releases a small metal ball. This ball falls into a wooden box and weighs down the gears. It causes the top box to spin the gear clockwise. This causes the bottom gear to spin counterclockwise. The bottom gear has a wrench attached. When the gears spin, the wrench hits a loose gear, sending it back into the robot's body. **(Step 11)**
   a. We started the energy transfer back down the robot. We are starting to wrap up the final steps, so we need our energy to make its way back to the base.
   b. We used three gears, a wrench, and a box made from scrap wood.
10. The gear hits a marble off a ramp. This marble falls down a second ramp and hits a golf ball off where it is resting. The ball falls into a cup and triggers a limit switch to be pressed by the lever. **(Step 12-14)**
   a. The energy here falls down the robot using various ramps. Again, the purpose of the transfers is to get us down to the ending.
   b. We used more scrap wood for ramps as well as a metal track.
11. At area 11, we have a lever. The golf ball falls into a cup at the right side of the lever pushing it down. The left side goes up. This is shown by the two arrows. The left side of the lever bumps a limit switch. **(Step 14)**
   a. The energy changes directions because of the lever. The limit switch will be a start to many electrical energy transfers.
   b. We used scrap wood to create the lever. We also used parts of a Vex robotic kit for the electrical steps.

12. The 1st motor, triggered by the 1st limit switch, spins and causes the hand's finger to curl up. The finger curls and presses a 2nd limit switch. **(Step 15 & 16)**
    a. The energy is transferred from the battery to the motor and limit switch. The energy is transferred through the tendon string and to the finger. Then, when the switch is hit, the energy is transferred to a 2nd motor.
    b. We used more pieces of the Vex robotic kits here. Our mechanical hand is made of scrap wood, dowels, pins, and string.
13. Our final big transfer of energy happens at our last step. The 2nd motor rotates and lifts the banner up. Once our banner flips up we have our wooden piece hit the computer to start our video. Our video then begins to play with Ty talking. **(Step 17)**
    a. The energy is transferred
    b. The energy again is transferred through the wires and to the motor. The motor rotates an axle, the axle is connected to wheels with rods that are attached to the banner. The banner lifts when the motor spins.
    c. We used a piece of fabric we bought from Walmart. We also cut our designs using a Silhouette sticker cutter and iron on vinyl.
    d. Once our banner flips up there is a wooden handle connected to the axle. The wooden handle then hits the computer to play our video.

Below is a more broken down description of the human half

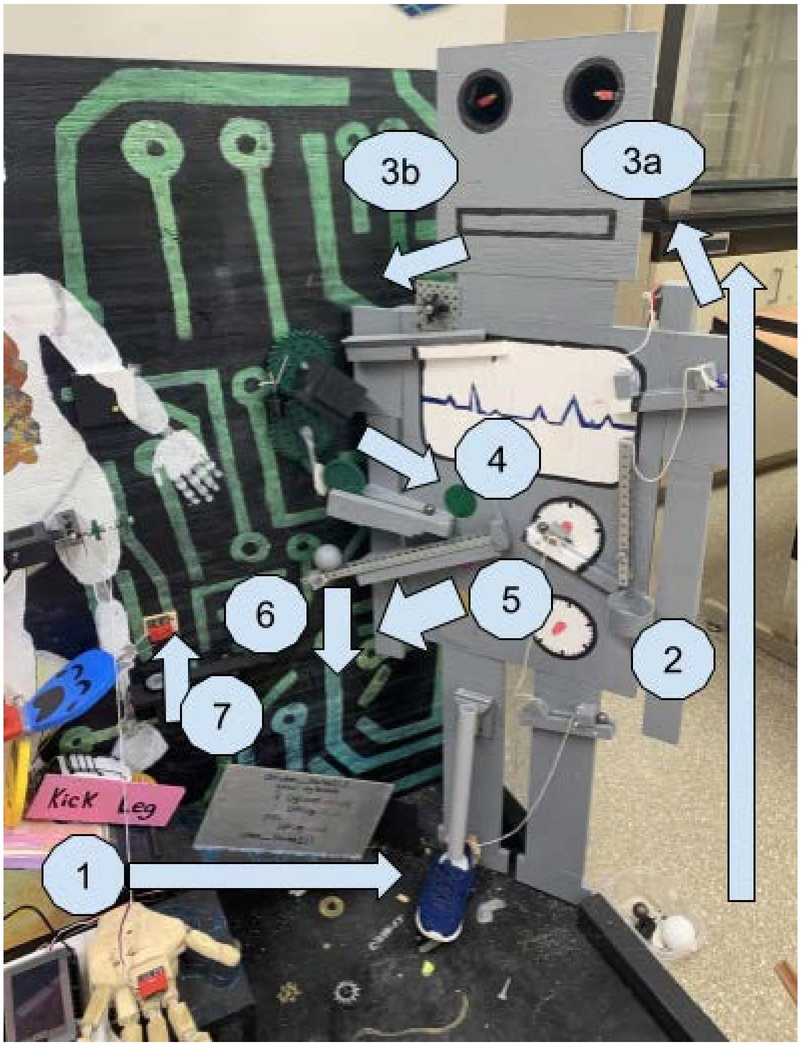
Arrows represent energy transfers.



1. At arrow one, marble will flow down the brain with the help of gravity. These will fall into a cup connected to a balloon on a pulley.
2. As the cup from one goes down, the balloon at area two will go up, changing our direction of energy.
3. Once the balloon is lifted up, it will push up the lever and cause a marble to roll down the tube. Then, it will follow arrow three and travel down that track. This marble started with potential energy; then, it transferred to kinetic energy. This marble fell into a cup lifting a gate.
4. At arrow four, our direction flips again. Golf balls are released down another track. They had potential energy when they were resting. It changed to kinetic the second they were released down the track. They are released by dentures and the food is sent down the esophagus.
5. The golf balls fall off the track and fall straight down into the clear cup. The weight of the golf balls mixed with gravity pushed the lever down.
6. The right side of the lever is pushed down; as a result at area six, the left side lifts up. This lifting causes the hammer to fall off.
7. When the hammer falls, it falls along the arrow seven. The hammer is gaining speed when it starts falling. It has enough momentum to hit the syringe and push air through the tubing and to the smaller syringe.
8. Arrow eight shows the complete transfer of energy from the human side to the backboard. The small syringes plunger will push out, continuing the transfer of energy to the metal ball.

Below is as more broken down description of the robot half

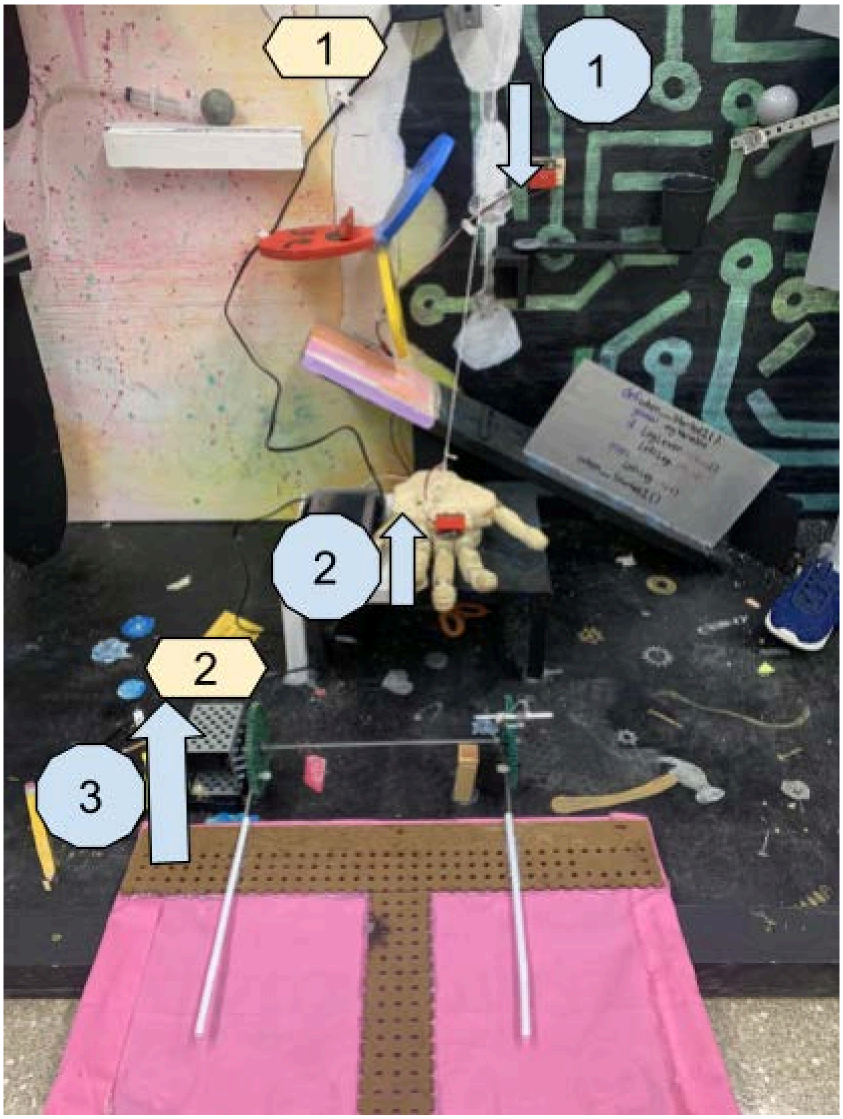
Arrows represent major energy transfers



1. The ball pushed by the syringe hits the paddle. The paddle hits the car and it slides down the ramp. The energy is transferred down the ramp and to the leg. The car collides with the lever and forces the prosetic to kick.
2. Once the leg kicks, it pulls a block off a ramp releasing a marble. The marble collides with a second block and starts the upward reaction. Here our energy is moved from the base of our robot back to the top.
3. At 3a the final block falls off. This block falls and clicks the limit switch. The limit switch then triggers the motor at 3b to spin, which releases a ball. The energy here moves across the robot's head and lets us start back down his body.
4. The ball released in step 3 falls into a box connected to a few gears. There is a wrench attached to the second gear, this wrench sends a gear sliding into the body of the robot. The gear collides with a marble. The energy is starting to move down the robot's body.
5. The marble slides down a second track and collides with a golf ball. This returns our energy to the backboard where we are able to start the sequence of our ending steps.
6. The golf ball falls down and lands into a cup connected to a lever. The weight of the golf creates enough force to push down the lever. Currently our force is going straight down.
7. With the lever, once the ball falls the other side can lift. The side of the lever going up presses a limit switch to start the electrical transfer of energy to our final coded steps.

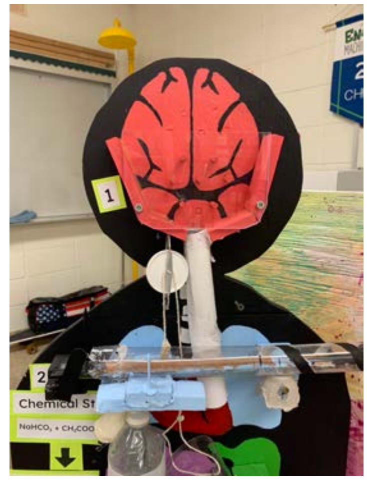
Below is the breakdown of our final steps

Arrows represent energy transfers
Yellow shapes label motors



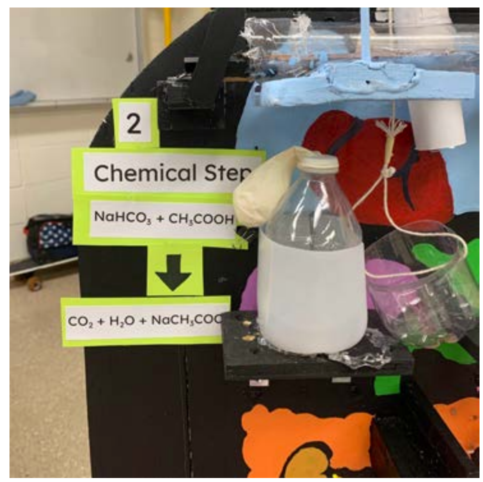
1. As shown previously, the limit switch is pressed. Once this happens, motor 1 starts to spin. This spinning is slowly tightening the string throughout the hand.
2. When the string is tight enough it will curl the finger of the hand. When the finger curls it will press the second limit switch. This switch tells motor 1 to stop spinning and tells motor 2 to start its rotation.
3. The motor is connected to an axle. The axle is connected to gears with beams to hold the banner. When the motor rotates it finishes our Rube by lifting the banner. A wooden handle is attached to the axle and hits the computer. The computer pushes the play button and our video starts.

3. List of Machine Steps



Step 1: A team member drops marbles into the Plinko Board in the brain. The marbles bounce around until they reach the end, go through a tube, and into a cup. The cup is on a pulley connected to a balloon filled with baking soda. When the marbles land in the cup, the cup will go down, pulling the balloon up. The baking soda in the balloon will fall into the bottle of vinegar.

Neurons bounce around in the brain, they travel down the brain stem. The brain tells the lungs to take in oxygen and expand.



Step 2: Advanced Component–Chemical Step Once the baking soda in the balloon reaches the vinegar in the bottle, it creates a chemical reaction. The carbon dioxide gas created by the combination of baking soda and vinegar blows up the balloon. Once the balloon blows up, it lifts a lever.

The lungs expand and they spread oxygen throughout the body through the blood and arteries.

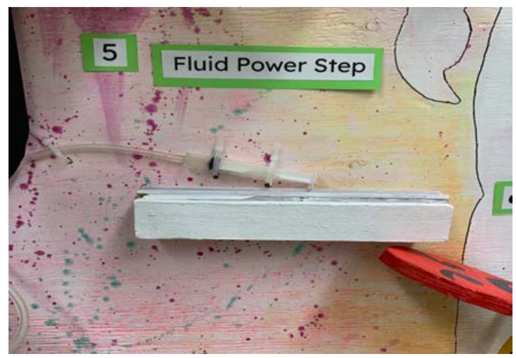
Step 3: Advanced Component–Mechanical Step Type #1: A marble is resting on a lever. The balloon causes the marble to roll down a tunnel and onto a track on the backboard. The marble continues to roll until it reaches the end of the track. Then, it falls into a cup connected to a pulley. On the other side of the pulley is a gate holding back two golf balls. When the marble falls into the cup, the gate lifts up and releases two golf balls. The golf balls roll down a track and fall into a plastic container.

The jaw is represented by dentures. Dentures mimic the human jaw and are a revolutionary piece of technology in human life. These open and release food down the esophagus and into the stomach.

Step 4: The golf balls roll down a track and fall into a clear plastic container. The weight of the golf balls pushes down on the plastic container and causes the hammer to fall off.

The food falls into the stomach where it is broken down into nutrients.

Step 5: Advanced Component–Fluid Power Step Once the hammer is tipped off of the lever above, it swings and collides with a syringe. The first syringe is connected with tubing to a second syringe on the back board. When the large syringe is hit, air moves from the first syringe, through the tubing, and to the second syringe. Once the air reaches the second syringe, the plunger is slowly pushed outward and starts a metal ball rolling.

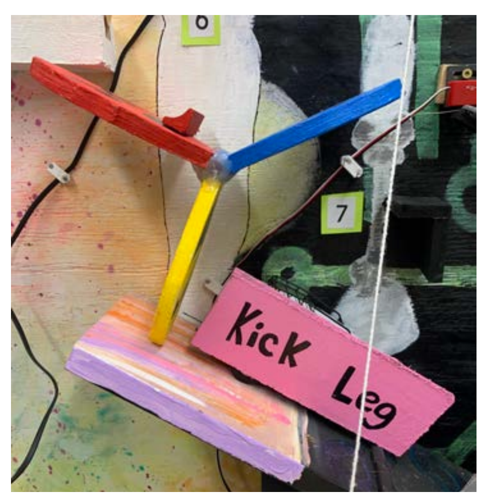


Toxins are released from the body.

Step 6: The rolling metal ball falls on to a paddle and causes the paddle to rotate.

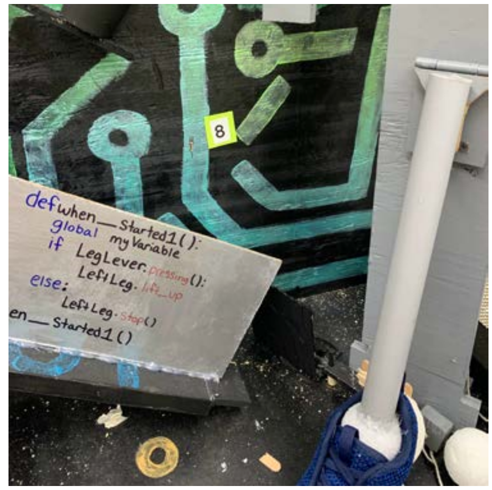
The ball causes a quick change of emotions. Emotions are one thing AI is trying to understand. Currently neural networks are the best thing AI has to mimic these quick changing emotions.

Step 7: The rotating paddle pushes a car down the ramp. The car has pseudocode on it telling the leg to kick.

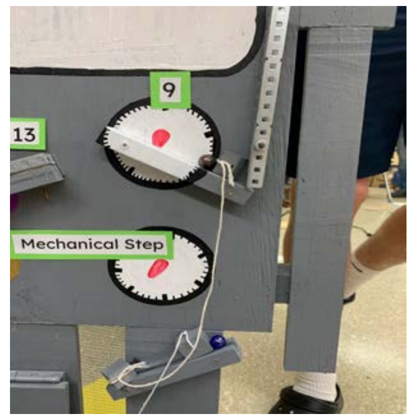


"Kick Leg" represents human language and pseudocode. Through pseudocode programmers are able to explain their thoughts in our language before converting to python coding to operate a robot or machine.

Step 8: The car with pseudocode travels through the tunnel and changes it into python code. This tells the leg to kick when the lever is hit. When the lever is pushed, the leg kicks outward. The leg is tied to a block. When the prosthetic leg pushes out, it pulls the block off its ramp. This block releases a marble to collide with another block.

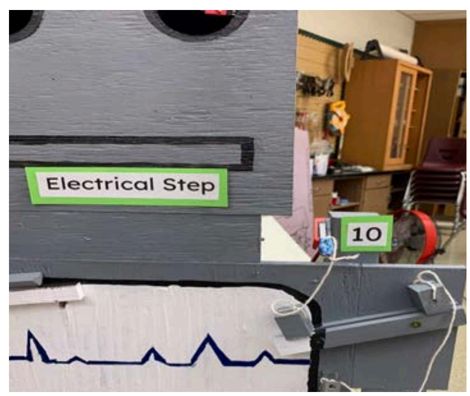


The pseudocode goes in, turns to python language, then the robot kicks his prosthetic leg. Prosthetic limbs have been revolutionary to amputees. Researchers mimicked the function of human limbs and made them out of tech to benefit people. This starts the trigger of the three robotic functions, first sense.



Step 9: Advanced Component–Mechanical Step Type #2 The released marble collides with another block, knocking it off as well as the block tied to it. The block again falls then collides with a lever. The lever pulls off a block above, releasing another marble. The final marble released collides with the final block connected to a limit switch.

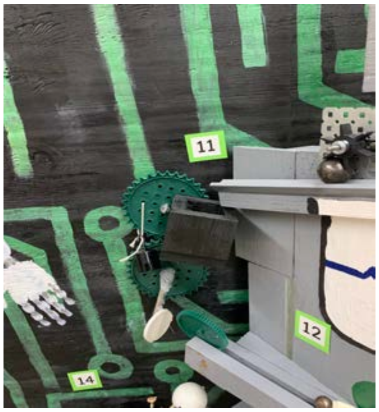
Here the second robotic function is shown, think. The robot has sensed now it is "thinking of what is next".



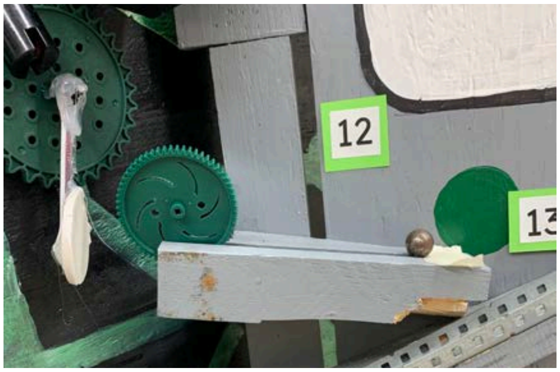
Step 10: Advanced Components–Electrical Step When the block falls off, the limit switch is triggered, and the triggered limit switch starts a coded program. The program turns on the robot's eyeballs, waits two seconds, and spins a motor to release a metal ball for our next step.

The last thing a robot does is act. The robot's action was to turn on his eyes and spin a motor to continue his process.

Step 11: Advanced Component–Mechanical Step #3 The metal ball released falls into a box. The added weight to the box causes the gear attached to spin. Below is another gear with a wrench attached. The two gears are meshed together, so when the ball lands in the box, it causes both gears to spin; and the wrench collides with a small gear.

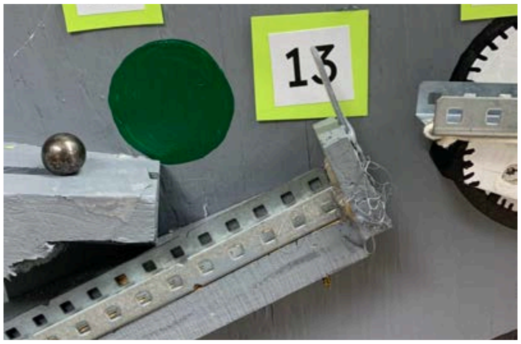


Once the robot turns on, he has some issues. First a ball falls out of his head. This causes his gears to spin. The robot's creator saw this ball fall out so they wanted to fix it. They grabbed their wrench and put a gear back in his body.



Step 12: The small gear rolls down a channel and bumps a marble off its platform.

Little did they know, another ball was loose inside. When they placed the gear in, a ball rolled back into its place.



Step 13: The marble rolls down one track and falls to the track below. Here, it hits a golf ball.

As things were loose in the robot, a large nut fell out. The creator solved the robot's troubles and now it is fixed. Technology needs humans just like humans need technology

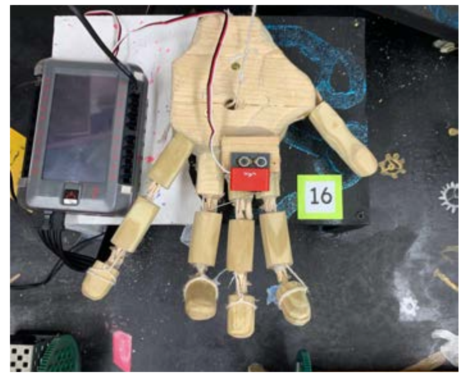
Step 14: Advanced Component–Mechanical Step Type #4
The golf ball falls into a cup. The cup is on one side of the lever; on the other side is a washer used to keep the lever in balance and hit the limit switch above. When the ball falls into a cup, the lever lifts and hits the limit switch.

This represents the balance that humans and technology currently have. They are working together to better our society every day.

Step 15: The limit switch from the last step tells a motor to turn. This motor is connected to the ropes in the hand. It winds up the rope and causes the finger to curl.

The string through the hand represents tendons in a human hand. This represents how the human mind can signal a prosthetic to move as a normal hand would.

Step 16: The finger that curls hits another limit switch. This limit switch triggers a second motor. The second motor lifts up our banner.



Prosthetics can mimic motions of a real hand. Our prosthetic's finger is curling up to press our switch.

Step 17: The final step is the motor lifting the banner and our video starting. The banner is connected to a motor on a large axle. The banner design was created using a Silhouette cutter. It has our team name on it, as well as all of our faces. For our faces, we used our Snapchat Bitmojis that we were able to cut out. We also hooked a wooden handle onto the axle of the wheel. The wooden handle then hits the video to play.

We directly used technology to benefit us here. We were able to transfer our faces to a computer program to cut them out and turn them into iron on stickers. We also want to leave you thinking with a quote, "The technology you use is not impressive, the experience you create with it is everything. Our wooden handle then hits the computer to start our video.

4. Cost of Machine and Percent of Recycled Materials Used

Item	Quantity	Origin	Cost
Colored Paint	15+ Colors	Repurposed	$0.00
Netting	1	Repurposed	$0.00
Craft Sticks	6	Repurposed	$0.00
Flat Matte Black Paint	1 can	Repurposed	$0.00
Valspar Quart Grey Paint	About 1 Cup	Purchased	$6.25
Screws	About 60	Repurposed	$0.00
Plywood 4x8	1	Repurposed	$0.00
Plywood 2.5 x 4.5	1	Donated	$15.00
Scrap Plywood 4 x 8	1	Purchased	$1.00
2x2 boards	8	Repurposed	$0.00
Nail Gun (nails)	40+	Purchased	$3.00
Lacquer Clear Coat	1 can	Purchased	$7.00
Dowels Pieces	7	Repurposed	$0.00
Plexiglass	1	Repurposed	$0.00
Pulley	3	Repurposed	$0.00
Water bottle	4	Repurposed	$0.00
Balloons	1 pack	Purchased	$1.00
Baking Soda	10 grams (Used about 10 times)	Purchased	$0.30
Vinegar	20 milliliters (Used about 10 time)	Purchased	$0.20
Wood Trimming	4 Pieces	Repurposed	$0.00
ChipBoard	1 box	Repurposed	$0.00
String	Many Pieces	Repurposed	$0.00

Fishline	Many Pieces	Repurposed	$0.00
Vex L Brackets	3	Repurposed	$0.00
Golf Balls	3	Repurposed	$0.00
Car track	1	Repurposed	$0.00
Car	1	Repurposed	$0.00
Wooden Boards	5	Repurposed	$0.00
Wooden Blocks	8	Repurposed	$0.00
Metal Vex Bar	1	Repurposed	$0.00
Hammer Head	1	Repurposed	$0.00
Plastic Straws	2	Repurposed	$0.00
Syringes	2	Repurposed	$0.00
Tubing	1	Repurposed	$0.00
Plastic cups	1	Repurposed	$0.00
Paper Cups	6	Repurposed	$0.00
Gears	7	Repurposed	$0.00
Limit Switch	3	Repurposed	$0.00
VEXnet space brain	1	Repurposed	$0.00
Vex 2 wire 393 motor	1	Repurposed	$0.00
Vex V5 Brains	1	Repurposed	$0.00
Vex V5 Motors	2	Repurposed	$0.00
Axles	5	Repurposed	$0.00
Metal Tracks	3	Repurposed	$0.00
Zip Ties	6	Repurposed	$0.00
Scotch Tape	1ft	Repurposed	$0.00
Hot Glue	5 large sticks	Purchased	$3.00
Scrap Wood	Around 20 Pieces	Repurposed	$0.00

Paper	3 Sheets	Repurposed	$0.00
Felt	2 Pieces	Purchased	$1.00
Masses	2	Repurposed	$0.00
Binder clip	1	Repurposed	$0.00
Plastic Candy Cane Tub	1	Purchased	$2.00
Marbles and Balls	15	Repurposed	$0.00
Heat Transfer Vinyl	½ Roll	Purchased	$2.50
Cotton Fabric	1	Purchased	$1.40

<u>Cost Analysis</u>

Plywood: $16
Paint and Clear Coat: $13.25
Felt: $1.00
Hot Glue: $3.00
Baking Soda and Vinegar < $0.50
Balloons: $1.00
Nail Gun Nails: $3.00
Plastic Candy Tube: $2.00
Heat Transfer Vinyl: $2.50
Cotton Fabric: $1.40
Total Cost: $43.65

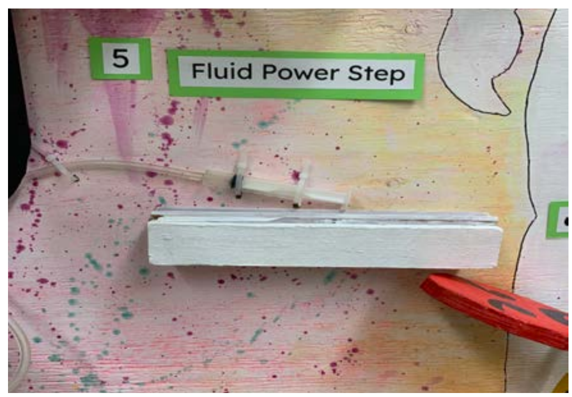
<u>Percent of Recycled Materials:</u>

Total Number of Materials Used: 177
Total Number of Recycled Materials: 159
Percent Recycled: 90%

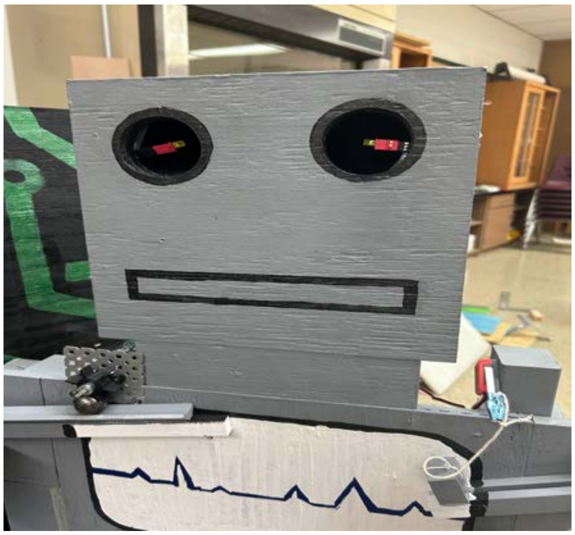
*****_When totaling items, quantity number is used except for screws, nail-gun nails, fishing line, string, baking soda, and vinegar. They were totaled each as one, due to being used or bought in bulk._

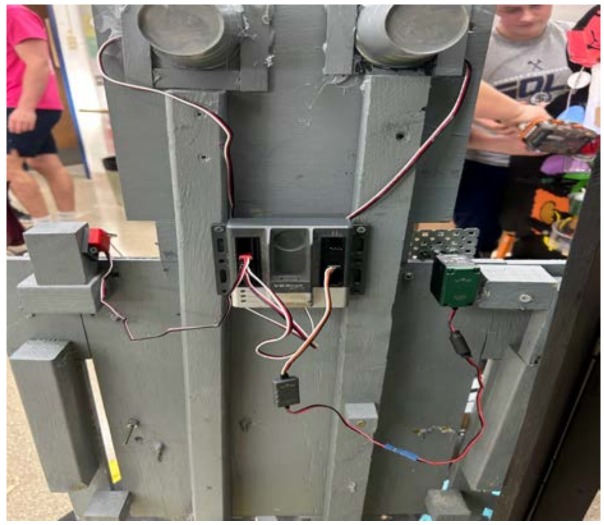
5. Applied Stem Processes

Fluid Power Step 5: For our fluid power step we faced a couple challenges, they were spacing and consistency. We used the engineering design process to solve both. The first issue was spacing. We had to find a way to move our energy from the human to the backboard of the rube. As we brainstormed solutions we found that the tubing from our fluid power step is flexible and could be used to cover this distance. The second problem we solved was the inconsistency of our syringes. The hammer would struggle to have enough power to push the larger syringe in far enough to push the smaller one out. The solution we came up with was to have equal size syringes on both sides. This would work because of Pascal's Law. Pascal's Law states that $P=F/A$, P being pressure, F being force, and A being cross sectional area. This meant that all of the force from the hammer would be transferred through the tubing and to the second syringe. The force was great enough to push our metal ball more consistently. Since we used the smaller syringe, we had to also create a buffer behind it to the plunger did not rub against our wooden block. We have found we need to start the input syringe's plunger partially in and also work the syringes right before we run our machine.



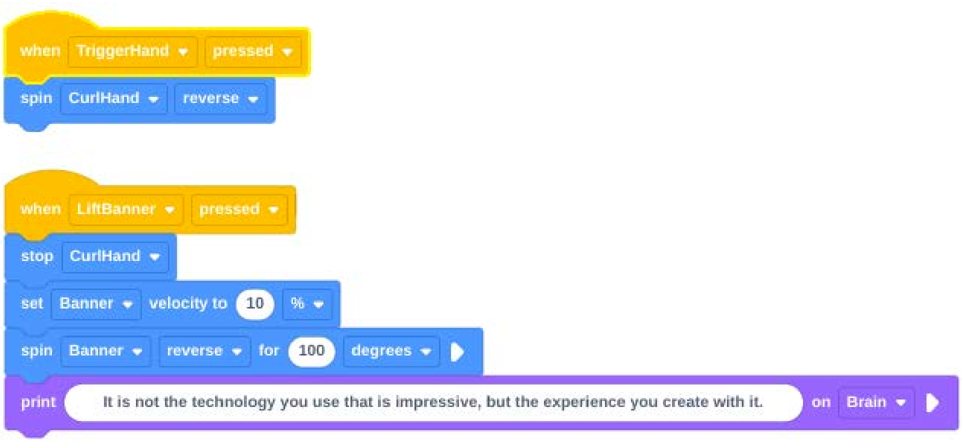
Electrical Step 10: As we were brainstorming, we knew we wanted to turn on the robot's eyes and created another mechanism to continue our chain of steps. We had access to VEX Robotics materials and decided on using two LED lights and a motor. These were all connected to our VEXnet brain. Caden, the only one in our group who knows how to code, tackled this step. Our motor and lights are all powered by a 7.2 volt battery connected to the brain. The code was programmed on RobotC which uses JavaScript and C++. First, Caden created an infinite while loop, so we would not have to re-download the code to the brain. Instead, it will repeat the process whenever the limit switch inputs a 1 to the first digital port in the VEXnet Brain. When the limit switch is pressed down, its sensor value is 1, and the code will begin to run. An if-else statement was created, so when the limit switch is forced down, the code will begin, but when it is released, the code will finish and not start over until the limit switch inputs a 1. Two LEDs connected to the digital ports 2 and 3 and will turn on immediately after the limit switch is pressed down. They will turn on for 2 seconds. Then, the motor will rotate clockwise for another 2 seconds. When the motor stops, the LEDs will also turn off. We used a 393 Vex motor that is connected to the first motor port in the brain. The first idea was to use mini breadboards and wire LEDs in a parallel circuit. We believed a parallel circuit would be the right choice just in case one of the LEDs was to lose connection; the others would stay on. We then found VEX LEDs and realized it would be much easier, faster, and cleaner to use them.

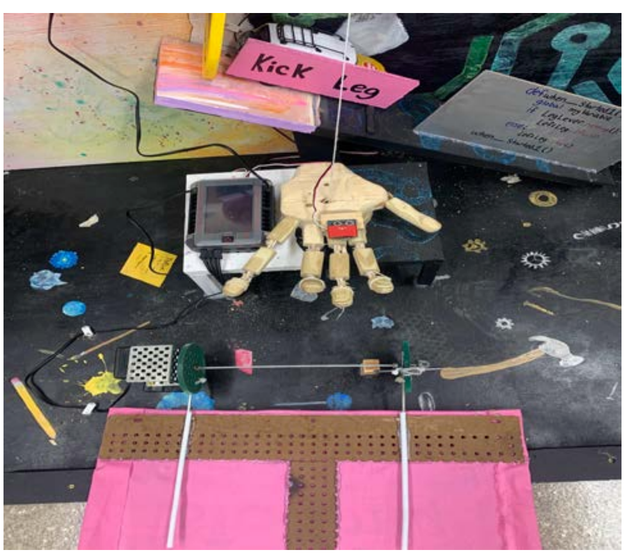




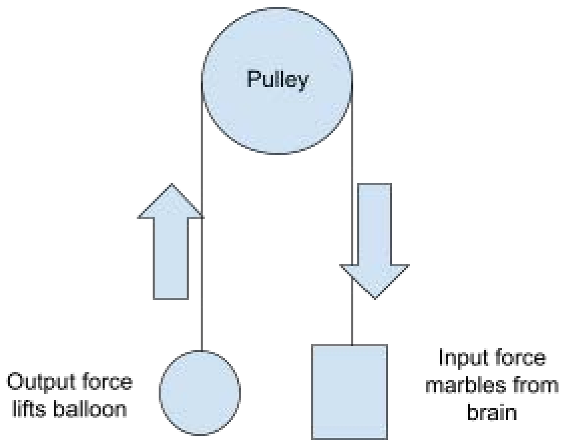
```
#pragma config(Sensor, dgtl1,  limitSwitch,    sensorTouch)
#pragma config(Sensor, dgtl2,  lED1,            sensorLEDtoVCC)
#pragma config(Sensor, dgtl3,  lED2,            sensorLEDtoVCC)
#pragma config(Motor,  port2,           motor1,        tmotorVex393_MC29, openLoop)
//*!!Code automatically generated by 'ROBOTC' configuration wizard               !!*//

task main()
{
while (1==1)                          // Creates loop so code can run continuously
{
  if (SensorValue(limitSwitch)==1)    //Code starts when limitswitch is pressed
  {
    turnLEDOn (lED1);                 //LEDs turn on
    turnLEDOn(lED);
    wait(2);                          //2 seconds of only LEDs on
    startMotor(motor1,25);            //Motor starts
    wait(2);                          //Motor and LEDs run for 2 seconds
    stopMotor(motor1);                //Motor turns off
    turnLEDOff(lED1);                 //LEDs turn off
    turnLEDOff(lED2);
  }
  else                                //If limitswitch =0 or is not pressed then nothing runs
  {
    stopMotor(motor1);                //Motor turns off
    turnLEDOff(lED1);                 //LEDs turn off
    turnLEDoff(lED2);
  }
}
}
```

Electrical Step #2 Steps 14-17: After our first competition we wanted to incorporate more technology into our ending steps. When solving this problem we used the engineering design process. First we defined our problem, our problem was our ending step was inconsistent and was not very impressive. Then we brainstormed various solutions. Our first idea was to have a long banner rolled up, a motor would spin a few gears to allow our banner to unroll. We also thought of trying to flip a banner up or spin it around. We ended up choosing a solution where we had a series of limit switches that triggered the banner to lift. Once we chose to create this solution we had to figure out how to implement it into our current steps. After some testing of codes and logistics we figured out our solution. We will have the lever that used to hit a weight off click a limit switch. This limit switch will spin a motor to curl the finger of our hand and press a second switch. This switch will shut off the first motor then spin a second one hooked to our banner. The banner is connected to an axle which has two vertical axles attached to the banners brace. After we completed the build the next thing was to create a code. We used Vex V5 block coding to complete this project. Maya tried many codes, she tried if-else statements, broadcasting to start the second sequence, and ended up creating actions directly connected to the input of a limit switch. Once this code was built after a lot of trial and error the new last steps worked!





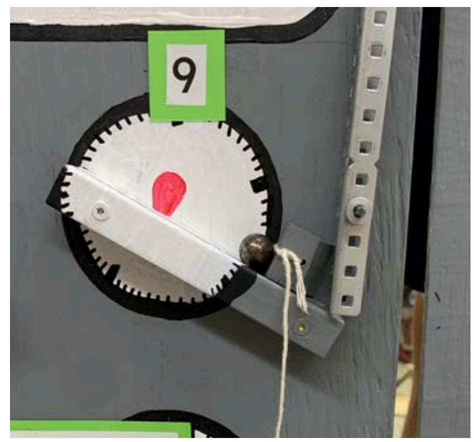
Mechanical Step Type #1 (Pulley) Step 1: Our very first step incorporates a pulley. We wanted a way for the marbles falling out of our brain to lift up our balloon. We used a fixed pulley; this type of pulley has a mechanical advantage of one (*Pulleys-Types and*, 2023). It has a mechanical advantage of one since the input force needed to lift an object is the same force the object creates. For example, if the balloon weighs 25 grams, we need over 25 grams of weight to lift it. This made it hard for us to balance the balloon down and our cup up. We had to make sure the balloon weighed more than the cup. We had to make sure that we put enough baking soda in the balloon to weigh down the cup. Neither side had any advantage due to the type of pulley. Once the pulley was working, we noticed the marbles weighed too much, and they would pull everything down with them. To combat this, we screwed a small plywood platform just below where the cup needed to end. This stopped the cup from pulling everything down and the marbles going everywhere.



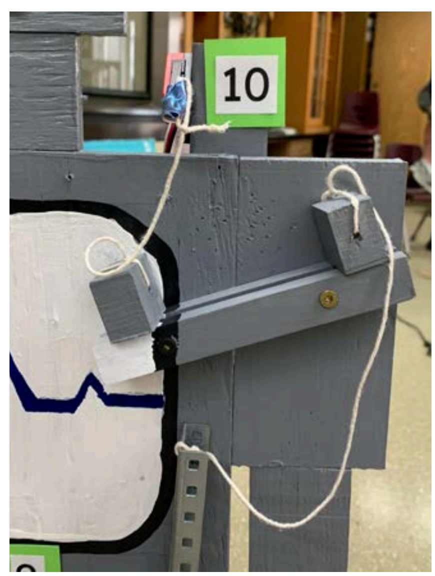
Mechanical Power Type #2 (Inclined Plane) Step 8-10: Kallen and Jaxon found an innovative way to create an upward reaction using many marbles and inclined planes. They knew the human side was going to end at the bottom of the project. Kallen and Jaxon were trying to figure out something that could bring the potential energy back up to the top. This was their goal and what they geared the STEM process towards. They started the research piece by looking at multiple videos for ideas. They came across an upward motion that used blocks holding back marbles that would hit blocks at the end with a string attached to higher blocks (DestructiveCreativity, 2020). This step works when a lever, horizontal to the ground, is tied to a block holding back a marble at the top of an inclined plane. This inclined plane is sloped at around 45 degrees; the slope allows the marble to gain enough speed to push the block off. There is then a block at the bottom of the inclined plane tied to a block at an incline plane sloping at 45 degrees in the opposite direction holding back a marble. The marble is released into a lever that has a string attached to a block at the top of the robot, also on an inclined plane. When this marble is released, it hits a block with a string tied to a limit switch. When the block falls off the inclined plane, it clicks the limit switch, starting the electrical step. When creating and testing their solution, the upward reaction, they had a few problems. Other than those small issues, everything ran very smoothly. At the beginning they didn't know how they were going to keep the marble in a straight path without it rolling off the side. They decided to notch the center of the inclined plane with a table saw. This allowed the marbles to have a lane to roll down. There was also a problem with one of the blocks staying in place. The marble weighed too much and would push the block. They used various things to create more friction. They painted all the blocks which made them stickier and created more friction between them and the inclined plane. Then, the block holding the steel marble was cut at an angle; this allowed more surface area to be rubbed against the inclined plane, again, creating more friction. These changes have made the reaction very consistent.

The gray leg of the robot is pushed by the lever. It pulls down a string connected to a block shown below. It pulls away the higher block letting loose the marble. It will collide with the lower block, which is attached to another block shown in the picture to the left.

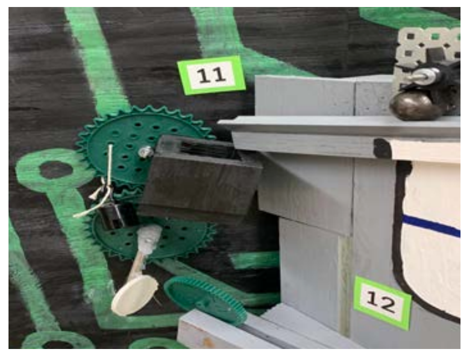
To the right is where another block is pulled, releasing a marble to hit the lever.



To the right shows the final marble reaction. The lever will pull the top block and release another marble. The marble collides with the lower block and triggers the limit switch.

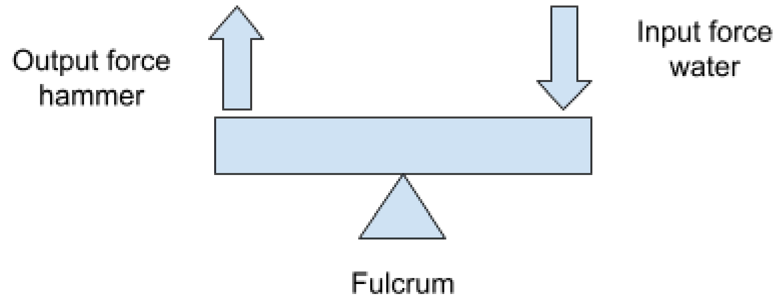


Mechanical Power Type #3 (Wheel and Axle) Step 11: Ty and Davis created a step involving three gears and a wrench. In step 11–the step following our electrical one–we wanted to incorporate a gear falling back into a robot's body to get the rest of the robot's body to work. We screwed two gears into the back of the wall, so one was on top of the other and created a gear train. When the two gears mesh, the top one spins clockwise; this causes the other to spin counter clockwise. We built a box for a marble to fall into the top gear, so it could spin the other gear that has a wrench on it. When the top gear rotates, so does the bottom, causing the wrench to collide with another gear. The wrench will knock the gear that's on a ramp off to set off the other steps. It is a wheel and axle because there is an axle in the gear and back wall that helps the gears spin. We did not use this for its mechanical advantage. First, we used a tray we found in the classroom, but it didn't work the best because the marble that we had to use wasn't small enough to consistently land in the tray. That's why we built one to be the perfect size for our marble. Another problem we ran into was the wrench wasn't hitting the gear every time, so we had to glue the bottom of a paper cup to it, so it would hit the gear every time.

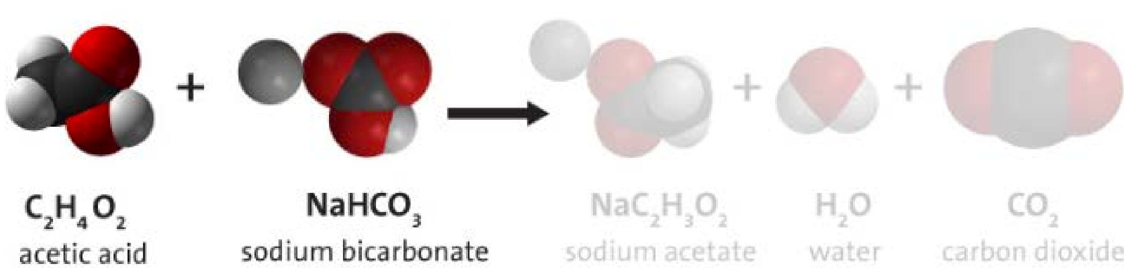


The marble falls into the box; the top gear rotates clockwise. The bottom gear rotates counter-clockwise. The wrench with the paper cup hits the resting gear.

Mechanical Power Type #4 (Lever) Step 4: We used many levers in our rube, but one of the hardest to master was our water and hammer one. This step required us to really use the STEM process. The problem we faced was we needed a weight to hit our syringe. Based on our syringes position, we could not just drop a weight, so we used the next step in the STEM process we researched. We looked through the other rubes done by past teams at our school. We saw one group use a swinging hammer. We really liked this idea due to the area we had available on our board. After we decided on using the hammer, we started to design our setup. As we were testing this one, we noticed we had to start with water due to the weight of the hammer. To help combat this, we gave the hammer less distance to the fulcrum and the water a greater distance. We can do this because to reach static equilibrium, $F_1 \times d_1 = F_2 \times d_2$. As we started to do full runs, we noticed that the hammer started to get stuck on the board. This was due to the curve of the hammer claw. It caused too much friction, and the hammer would not fall. We came up with a plan to fix this. We added a second lever. The golf balls tipped up the big lever, which collided with a small lever the hammer rests on. This is a first class lever due the the fulcrum being between the output and input force (*Types of Levers*, n.d.). Due to this step being very inconsistent, we removed the water, and the golf balls now fall directly into the clear container. We also cut an angle in the lever to limit friction on the hammer.



Chemical Step (Step 2): Our chemical step involves the combination of baking soda and vinegar. The reaction is $NaHCO_3 + CH_3COOH$ to $CO_2 + H_2O + NaCH_3COO$ (*Baking Soda and,* n.d.). To create the reaction, we have a balloon filled with 20 grams of baking soda and a bottle filled with 40 milliliters of vinegar. We had to increase the amount so the balloon blew up bigger. We have found that the two parts vinegar to one part baking soda creates the best reaction (*Is It Really*, n.d.). Once our pulley lifts up the balloon, the baking soda falls into the vinegar. When they meet, carbon dioxide gas is created. The chemical reaction is caused by the combination between the sodium bicarbonate (baking soda) and acetic acid (vinegar). Once they mix, they create bubbles and release carbon dioxide gas and leave a slightly changed liquid in the bottle, which is a mix of sodium acetate and water. With this step came many challenges. We had to figure out a way to make our balloon go straight up to lift our platform. To do this, we had to create guides for the balloon. We did this by using a plastic milk carton. This forced our balloon up rather than out. We still had roll in our lever, so we attached craft sticks to the bottom of the platform, which prevented the platform from turning on us. Again we tested to see if this would work; this time the crafts sticks jammed against the mike cartoon. Maya and Chloe created a cardboard platform under the craft sticks; this allows them to not get pinched and the lever not to roll. Our platform also had many modifications done. It started with a cardboard tube. Over time the cardboard shifted, and the marble would become lodged in the tube. We saw cardboard and tape were not the best solution for a tunnel. We decided to create a plastic tube that created minimal friction and allowed the marble to slide through the tube at any angle. Below is the chemical equation of our baking soda and vinegar.



(*Lesson 6.2: Controlling, (n.d.*

6.Reflection

Over the course of these past couple months, we all were challenged in different ways: whether it be our individual skills or our skills in a team setting. The degree of this project really tested us all. We agreed that our biggest take away was the ability to efficiently work as a team. This project brought so many challenges. The first was figuring out how to align all our diverse skill sets. It took about a week to find everyone's strong suits. Once we did this, we were able to divide and conquer sides of our rube. We all developed better communication and teamwork skills. We feel these will be very beneficial to us in college and in our careers. A lot of us want to go into the STEM field. The size and complexity of this project challenged us all. It has given us a better idea of the detail and thought process which is needed in many STEM careers. For the members not going into the STEM field, their biggest take away was the planning, organization, and time management. Everyone in our group learned and improved many skills needed in college and the workforce.

One of our biggest challenges–turned to success–was incorporating everyone's ideas. We found a lot of success with this by splitting our rube to sections. We had five sections: human, taken on by Maya and Chloe; robot's right side, done by Jaxon and Kallen; electrical step, created by Caden; robot's left side, taken on by Ty and Davis; and finally the notebook organized by Isabel and Chloe. By doing this, we were able to work on up to four steps simultaneously. This made the building process quicker and allowed freedom for any idea in each section.

Another challenge we faced was time. As the rube progressed, we found it very hard to make time for everyone to get together. Due to the weather, school was canceled or delayed many times. This cut into our in-class work time. We came in on multiple snow days in small groups. We created a Snapchat group to communicate with each other and set up time to work on non-school days. A few of us also put in extra time before and after class to work on perfecting the steps.

The most frustrating part of it all was nothing worked as planned. We had various sketches and ideas all throughout the semester, and we were sure they would work. We tested our steps as we put them together. We tested sides independently, and they worked great. During our first full run through, things that hadn't gone wrong went wrong. We ran it again, and even more things went wrong. We identified where the problems occurred and found everything that could go wrong. We worked to almost foolproof these steps. For example, our lever involved the hammer. We started with golf balls falling into water, the water displacing, a cup catching the water on a lever, and a hammer being knocked off. This step had worked consistently for us until our full runs. Here it would not work if the hammer was getting stuck on the lever, so we abandoned the water, cut the lever at an angle, and had to create a ricochet board. Now, it worked with our other steps. Our other step that continued to have problems was our chemical step. We needed to make this fool proof. We found the entire lever was lifting, not just where the marble was located. To fix this, we created a pivot using an egg carton and a screw. We also created a bigger area for our balloon to hit. Now, this step is working much better.

Another challenge we faced was our steps firing too early. The main one was Jaxon and Kallen's blocks. They would fall too early anytime the rube shook. All team members helped with this. A marble catch was created to ease the impact the large metal ball created. Kallen and Jaxon also figured out that flattening their inclined planes made it much harder for the blocks to fall off too early.

Overall, we all grew so much in our teamwork skills. We found out how to make very diverse skill sets work together. Our determination also grew immensely. We took so much time to perfect and improve this project even when it did not work as planned. .

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