SENIOR SCIENTISTS
(Sumner-Fredericksburg Team 1)

Team Members:

Joseph Blasen
Jesse Jones
Claire Rucker
Ava Schult
Alivia Seehase
Hillary Trainor
Myla Trask
Colton Zupke

Advisor:

Mrs. Amy Price

Contest Theme:

Human to Tech Transfer

Team Theme:

Senior Scientists bridging the gap between humans and technology!

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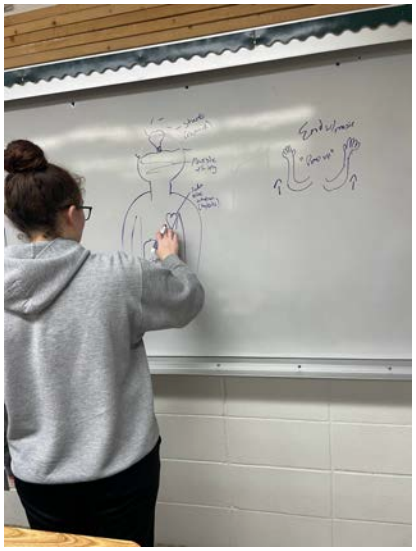
Description: **Page Number:**

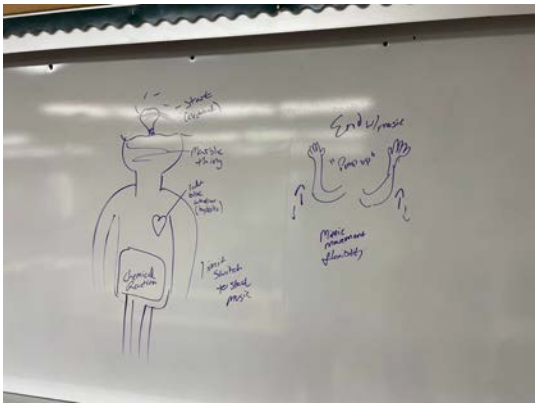
1. Planned Machine Design Sketch and Description

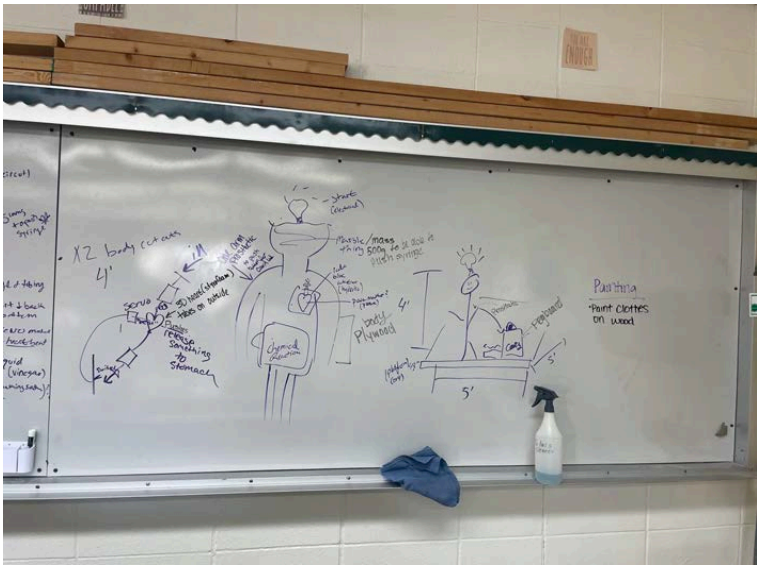
12-13-2023



The whole group got together before school to start planning our project. After hearing about this year's Human to Technology theme, we set out with the idea of incorporating a human body in our design.

These pictures include the first drawing of our design for our machine.





Each member of our group was assigned a main role.

Designing: Hillary, Ava, Myla, Alivia, Claire, Colton, Joseph, and Jesse

All members brainstormed ideas to develop an initial design that would change into the final design. Lots of ideas came from everybody as we tried to construct the machine.

Notebook: Alivia and Claire

These two members are in charge of documenting as the group makes changes and processes on the machine we are building. These members are the most organized of the group, so they are in charge of the notebook.

Builders: Colton, Jesse, Myla, and Joseph

All four of these members have multiple experiences in building and construction. Jesse and Colton handled most of the power tools while cutting out our design. Myla and Joseph also helped with construction and building steps.

Decorators: Myla, Hillary, Ava, Alivia, and Claire

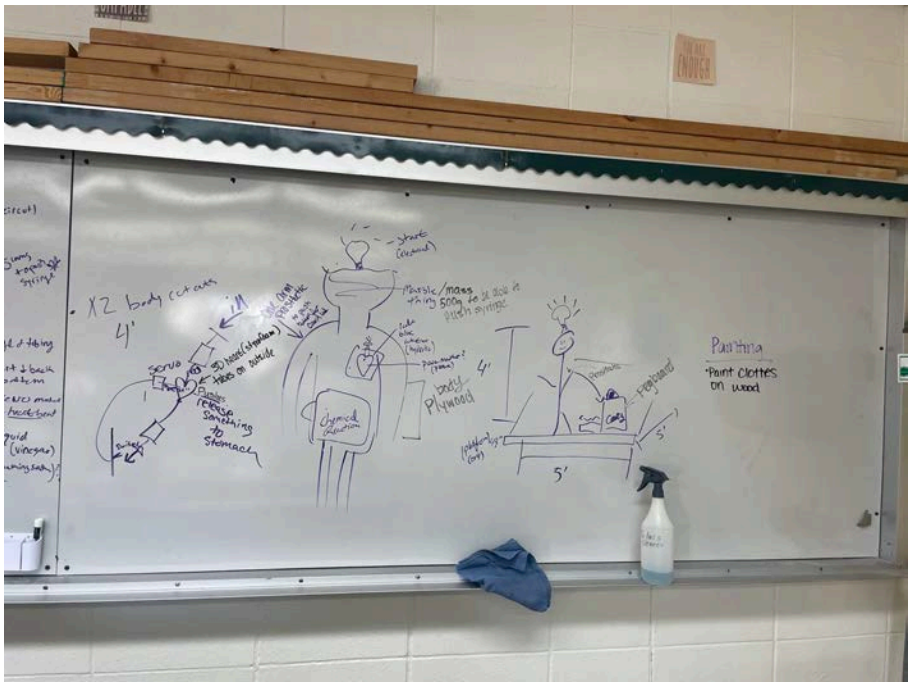
These members hold very creative minds. They are in charge of making the machine aesthetically pleasing. Painting the machine is their top duty.

Initial Steps:

We didn't have all the steps planned out with our initial design. Our steps were vague and outlined the big things we wanted to accomplish in our machine.

Person:

1. Light switch turns on the lightbulb at the top of the head
2. Triggers marbles rolling through tracks of the brain
3. Leading to fluids in the heart
4. Transferring to a chemical reaction in the stomach
5. End with the arms doing a dancing pump-up motion
    a. Soon changed to the hand hitting a button leading to a conveyor belt delivering cookies

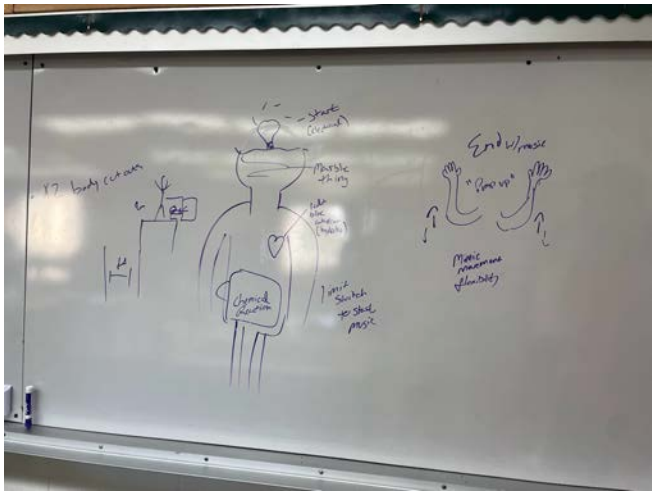


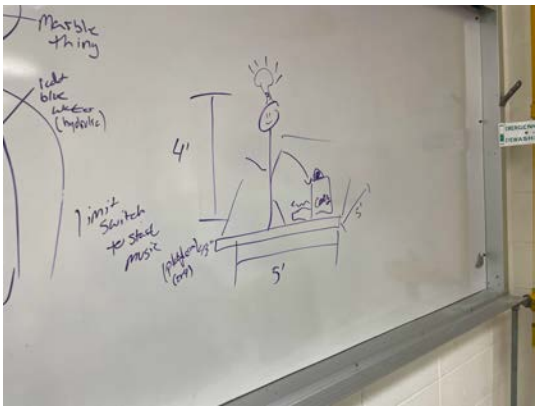
Anticipated Materials: Plywood, paint, cardboard, car tracks, toy cars, lightbulbs, balloons, baking soda, vinegar, syringes, pulleys, marbles, marble track, light switch, and paper.

Daily Log: Week 1

12-13-2023 (During Class)

We started deciding on the design and how we would pull our design off. We discussed how far apart the two silhouettes of people would have to be on our base. We decided around 2.5 feet between the two silhouettes. We talked about the ending of our machine as well. First, we decided to make it do a dance move; then, we wanted the arm to hit a button, leading to cookies coming out.





The picture on the left shows the dimensions of the silhouettes, a few steps on the human body, and how we wanted the arms to "pump up" at the end. The steps included a lightbulb lighting up, a marble track, a heart with red and blue fluid going through it using syringes, and a chemical reaction in the stomach. We also mentioned limit switches to start music when the arms pumped up. The picture on the right shows our ending idea after we decided the arms pumping up weren't going to work. It shows the dimensions of the body (4x5 feet) and the person's arm pressing a button to produce cookies from a conveyor belt. ***Note:** About a week into building our design, we realized we wanted the lightbulb to be the last step of our machine. We wanted it to be at the end to symbolize the ideas humans have to advance technology in order to improve human lives.

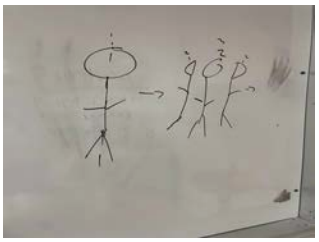
12-14-2023

Today, we started working on building our design. We wanted to get a jump start on our design.

All group members helped gather and carry supplies back to the classroom. Ava traced Hillary on paper to get an outline for our people in the design.

12-15-2023 (7:30 a.m.)

Our group had a morning meeting to figure out our design before we had time to work on it later in the day. We changed the design to three silhouettes of people lined up behind one another on a platform. These people represented the three aspects of the theme: humans, humans and technology working together, and technology.



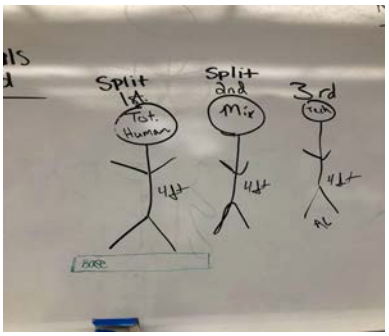
This picture shows the splitting of our silhouettes.

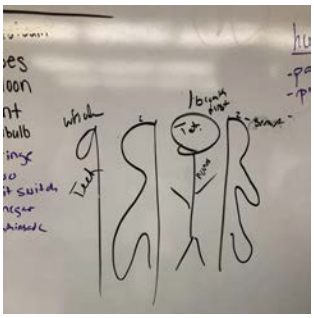
The first person is a human body.

The second person is a mix between technology and humans, tying them together.

The third person represents the technology humans use.

Then, we had to decide where we would put the steps we already had while trying to figure out more to place on the three people.





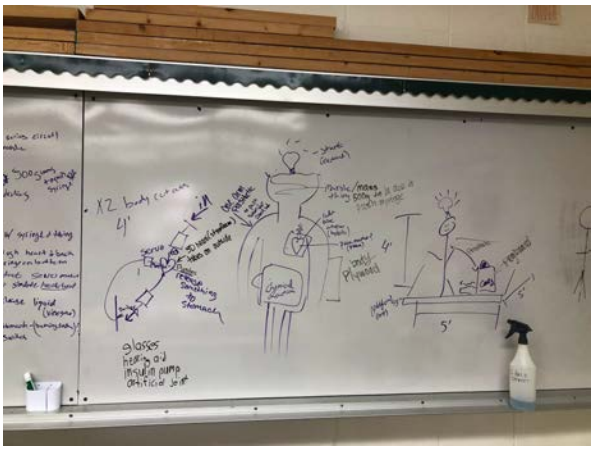
12-15-2023 (During Class)

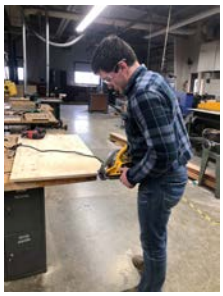
During class, we cut the traced body out, traced the body outline on wood, and came up with more steps.

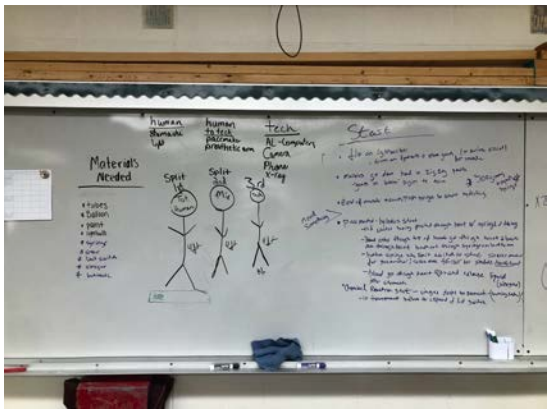
Myla and Jesse: They broke the base down, flipped it over, and broke it into pieces. Then they flipped the top piece, sanded the top and sides, and traced the body on the wood.

Hillary, Ava, and Jesse: They cut the paper outline of the body.

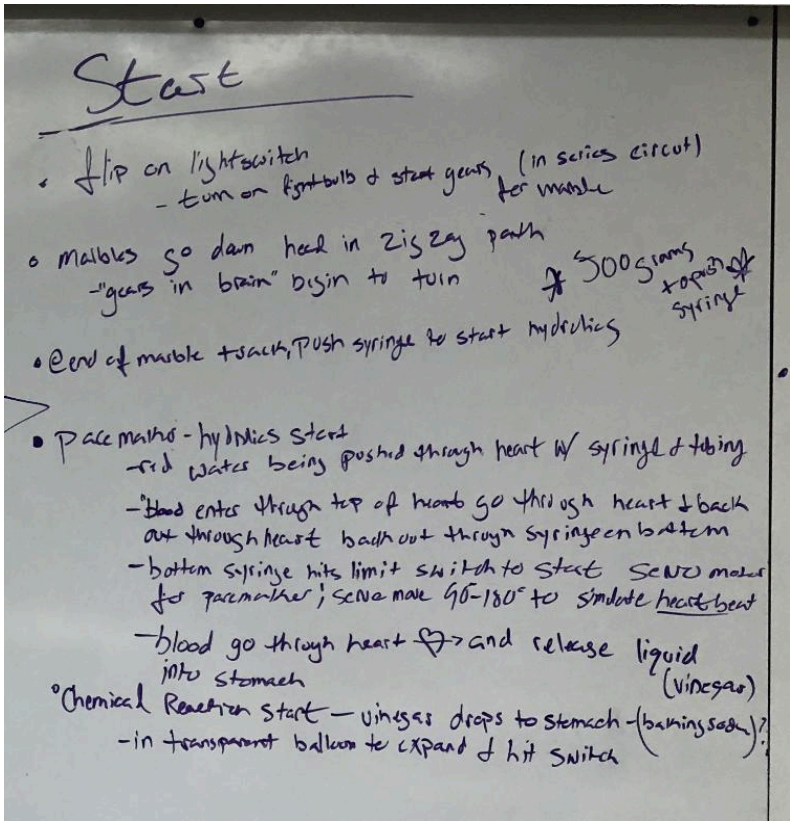
Claire, Colton, Joseph, and Alivia: They came up with more potential steps (focused on more technological steps).







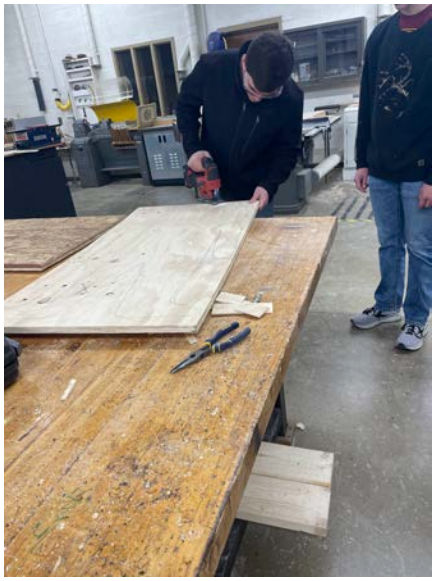
The far left picture on the bottom of the previous page depicts more steps we came up with. The added steps include the idea of adding a servo to a 3D styrofoam heart to make it "beat" like a pacemaker would do. We still kept the syringes pushing red and blue fluid through the heart but added a lever to the end where the second syringe would push the lever to trigger the next step. We added a note by the marble track that said to use a 500g mass in order to push the syringe. Another potential step we added was a prosthetic arm to push the button on the cookie conveyor belt. We wrote we wanted x2 of the body cutout, wanted each body to be 4 feet tall, and wanted the bodies to be made out of plywood. We also added a list of potential items to use in the second body: glasses, hearing aid, insulin pump, and artificial joint. The top left picture on this page shows our idea to jump from one body to three separate bodies. The first body would be a human, the second body would be a mix between humans and technology, and the third body would be technology. We also drew a flat base, labeled each body, and wrote we wanted the first two bodies to split. We wrote a materials list that included the following: tubes, balloon, paint, lightbulb, syringe, servo, limit switch, vinegar, and baking soda. Above each body we wrote what potential steps we wanted included. Human: stomach and light; Human to Tech: pacemaker and prosthetic arm; and Tech: AI, computers, camera, phone, and X-ray. The picture below shows the steps we wanted on our first body (this is pictured in the above picture on this page in smaller print).

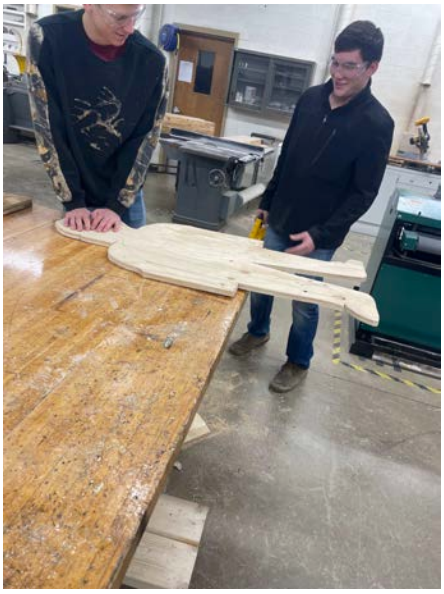


Daily Log: Week 2

12-19-2023 (7:30 a.m.)

Jesse and Colton worked on cutting out all three of the silhouettes for our design.



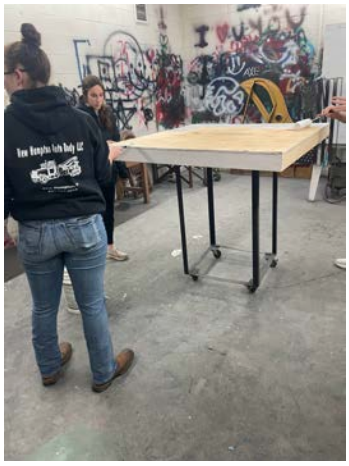
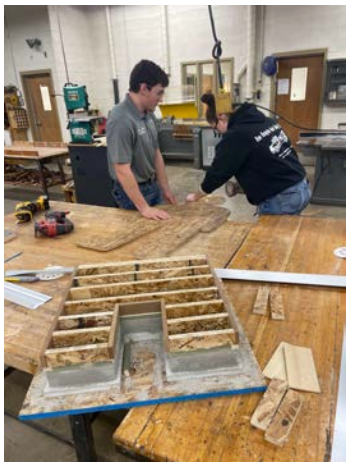


12-21-2023

A couple of our group members started priming the first outline we had cut out a couple of days ago to get it ready to start painting.

12-22-2023

Most group members came to another morning meeting to cut out the two other people's outlines, start priming them, and also prime the base of our machine.



12-29-2023 (12:45 p.m.)

Joseph worked on priming the boards that would be used as support for our silhouettes.

12-30-2023 (10:00 a.m.)

Myla, Alivia, Ava, and Colton worked on painting the pants and shirts for two of the silhouettes and painting the other silhouette to make it resemble a robot.

Jesse, this morning, worked on making the support for the silhouettes when they are attached to the base.

Daily Log: Week 3

1-3-2024 (8:00 am)

Alivia, Myla, Hillary, and Ava worked on tracing the image onto the base. Myla, Alivia, Hillary, and Claire worked together to outline and paint the image.

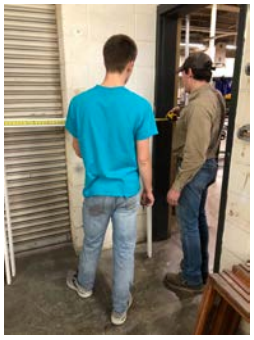






Hillary, Jesse, Colton, Joseph, Claire, Ava, and Alivia finished painting the support beams and the silhouettes.

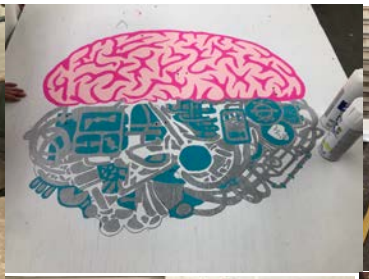




1-4-2024 (During Class)

All of our bodies, beams, and the base were dry and ready to be assembled. Jesse and Colton started by splitting the human body and mixed body in half.



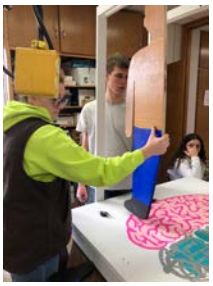




Myla and Alivia clear-coated the base to make sure the paint wouldn't scratch. Once that was done, everyone helped hold the support beams while Jesse screwed holes into the base.


Once the holes were screwed in, we took the beams off and transported the base, beams, and bodies to Mrs. Price's room. When we got to her room, we reassembled the base and beams. We got the human and transfer beams screwed onto the base but quickly realized we spelled technology wrong on the third beam. We put a primer coat over the word and decided to repaint it the next day.

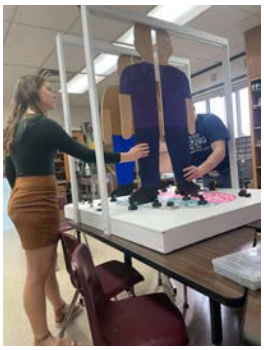
Jesse, Ava, and Hillary worked on figuring out the wheels on our bodies. Myla and Colton worked on figuring out the pulley system for our bodies.

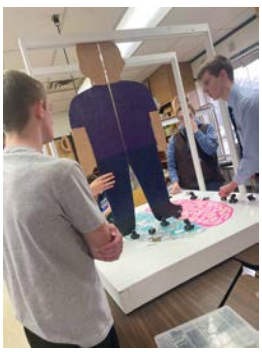


1-5-2024 (During Class)

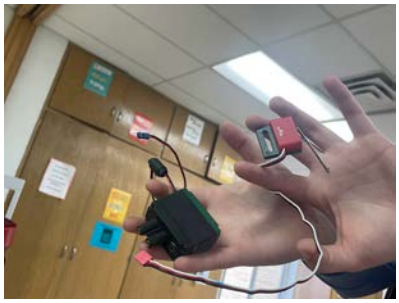
Jesse worked on attaching the wheels to our silhouettes to make them slide and split when the time comes.

Next, Ava and Colton helped Jesse place the silhouettes into the support beams.





While this was happening, Myla and Joseph were working on organizing the setup of the pulley system for the first silhouette. The second body splits using limit switches while the third body is whole (no splitting action is required).



Daily Log: Week 4

1-8-2024

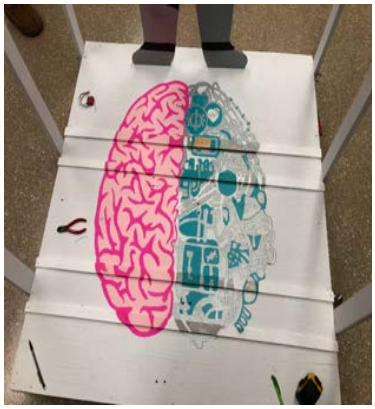
Jesse and Ava worked on leveling the supports while also reattaching them with bolts instead of the screws initially used. This way, when having to disassemble the machine, the wood will not strip.

Colton, Myla, Hillary, and Joseph talked about steps and then started working on putting gears on the first body. The gears will be used to tip a track full of marbles down a tube.

1-9-2024

Colton, Ava, Hillary, and Claire devised the final steps for our person. Once most of the steps were decided on, teammates started building and designing more steps. Colton, Claire, and Ava attached a track that would hold marbles to tip into a cup onto the gears.

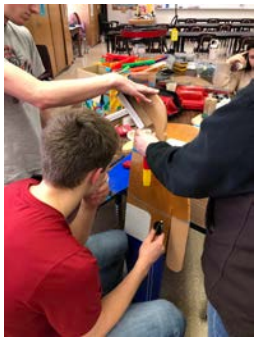
Jesse added wooden rails to our base to keep the bodies on track when they pulled apart. Ava, Hillary, and Claire painted the rails to make them blend in with the base. Our first body started to warp, so we placed textbooks on top of the wood to flatten it back out. The first body is made out of a different wood than our other two bodies. We think the different wood lost moisture when moved to the hot, dry environment of the Physics Classroom, and that's what made it warp.



1-11-2024

Myla, Joseph, and Colton added a cup attached to a tube to our first body. The cup and tube allow the marbles from the first step to travel through the body before falling into another cup, triggering a pulley system.

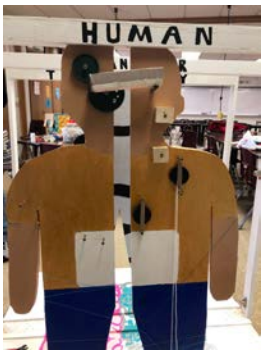
Ava and Jesse added the pulley brackets to the side of the beams.



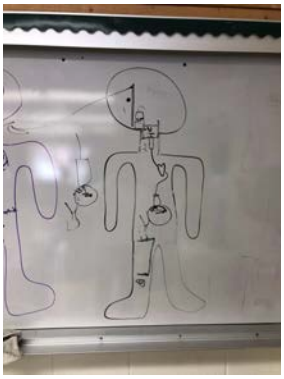
Daily Log: Week 5

1-15-24

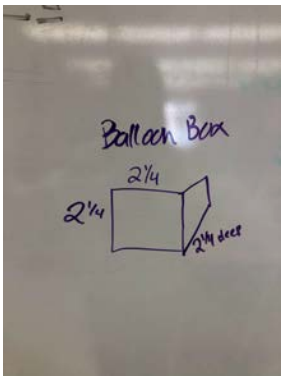
Our team realized the cup and tube weren't going to stay attached to the body at the correct placement for the marbles to fall through unless we had them backed by some sort of material. Colton and Myla came up with an idea to attach wooden blocks to the body and zip-tie the cup and tube to the blocks. Jesse added screws to the body where the pulleys would be attached, and Colton added screws where the car track would be attached.



Colton, Claire, and Ava drew steps for the second body. The steps incorporate biological and technological processes. We thought of using a catheter as a step and syringes to start a water wheel. Claire and Ava designed a box for the first body to hold the balloon so it would expand in the direction we wanted it to.

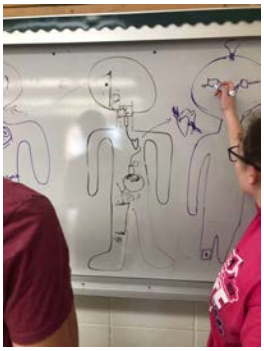


The picture to the right shows the drawn-out steps of the second body. The body starts with a string attached to a weight, pulling the weight off a platform and onto a syringe. This pushes air through the syringe into another syringe (the syringe system goes through a heart). The second syringe pushes on a water wheel, which dumps water into a cup sitting on a lever. The lever is attached to another lever and tips down when the cup is filled with water, allowing the second lever to tip up. That is all the farther we got with the steps today.



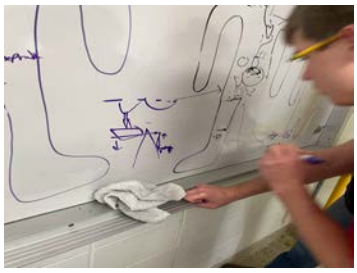
1-16-24

Myla and Colton started brainstorming ideas for our third body, and Ava, Hillary, Claire, and Alivia worked on the baking soda/vinegar ratio for our chemical reaction. The steps Myla and Colton came up with use different aspects of technology. They have USBs falling down a ramp, a servo turning a flap, and a light switch turning on a lightbulb as the last step.



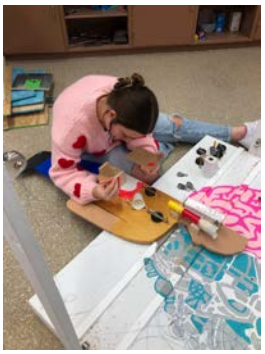
1-17-24

Our group worked on figuring out how to connect the bodies to one another and what steps we needed to take to separate the first two bodies.

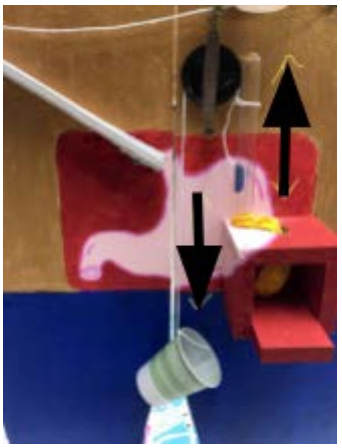


1-18-24

Hillary, Ava, Alivia, and Claire painted the white space on our first body to look like a stomach. Jesse attached the balloon box to the first body and figured out where the weight should sit on the second body. Myla worked on forming a water wheel out of popsicle sticks, cups, and wooden dowels. Colton and Joseph worked together to finish out the steps on the third body. Some of the steps they thought of included using magnets to release a lever holding a car back from going down a ramp and using a series of wooden blocks hitting one another to release the lever.



1-19-24



We decided to do a test run of our first body to see if all of our steps worked and connected to make our body pull apart. We found out that all of the steps worked except for one. The cup we had the car falling into was too small, and the car tipped out of the cup before activating the pulley, resulting in the test tube not dumping vinegar into the balloon. We decided to add a bigger cup with a weight attached to it to keep the car in the cup in order to activate the pulley system. The yellow arrows in the picture to the right show how the test tube should be standing upright in order to dump vinegar into the balloon and how the cup should fall directly down in order for the test tube to stand upright. When the car didn't stay in the cup, it didn't allow the test tube to stand upright like the picture depicts.

Daily Log: Week 6

1-22-24

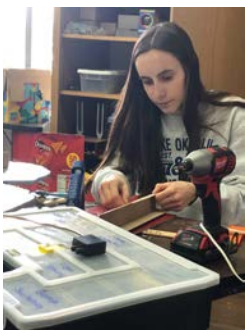
Myla, Colton, and Hillary started figuring out how to attach the water wheel and where the syringes should be placed on the head so that the weight would hit the syringe in the right spot.

1-23-24

Myla and Colton finished attaching the water wheel and made sure it spun when connected to the body. Hillary and Ava worked on making the funnel opening bigger for the catheter to make sure the water wouldn't spill out. Jesse and Joseph worked on figuring out the pulley system for pulling our bodies apart.

1-24-24

Jesse continued to work on the pulley system, and Hillary worked on a barrier for USB parts to slide down. Colton and Myla realized the wheel needed a platform for the syringe to push on to spin it, so they removed the wheel and added that. Joseph worked on building a box for the third body.



1-26-24

We finished the second body today. Ava brought in a catheter to connect the funnel. Colton and Hillary built a platform for the catheter to sit on. Myla built a lever system for our car to sit on/be released from. Colton also wired the limit switch at the bottom of the build.

Daily Log: Week 7

1-29-24

Myla and Joseph worked hard to build the steps and attach them to the robot for the third body. They built multiple levers, platforms, and supporting pieces. They also attached a syringe system to the body using zip ties. Jesse continued to work on the pulley system for the first body until it was perfected (he needed to add more weight to the stack that falls off the stomach platform).

1-31-24

Ava, Hillary, and Colton ran a test for our second body and realized most of the steps worked except the first step: when a string pulls cardboard from underneath a weight, the cardboard didn't move out from underneath the weight like it was supposed to. We also realized the cup attached to the funnel had a leak, which made water spill everywhere. Claire worked on hot gluing the gaps between the cup and funnel in order to fix the leaking problem. Colton came up with a better idea for the first step of the second body: Using a string attached to the first body; it would pull a weight over and onto the plunger of the syringe system, starting our second body. Myla and Joseph continued to work on the third body (Myla attached a light switch to the bottom of the third body and wired it to a battery and lightbulb).

2-1-24

Colton created a different platform for his new idea on the second body and got that process to work. Our second and first bodies are now complete and run smoothly. Myla and Joseph finished the third body and put it on our platform. We still need to test run the third body, and we plan to do that tomorrow, 2/2.

2-2-24

Myla and Joseph tested the third body, and it worked! We spent the rest of the class time cleaning up a few steps and making sure everything worked as we wanted it to.

2-4-24 (3:00-5:30)

Our group came in to do a test run of all the bodies connected. The test run went okay, but we kept having problems with the water wheel, so we decided to get rid of the water and use marbles instead. We are now using a bigger funnel so the marbles can fit through the opening. The marbles will fall out of the water wheel into a funnel. They will go through the funnel and into a plastic cup that sits on the platform hooked to a lever.

Daily Log: Week 8

March 18-March 22

Throughout this whole week, Myla, Colton, and Joseph reconstructed our third person. This was our main issue in competition, so that was one of the more pressing issues we needed to change. The team worked to reconstruct certain steps that were causing trouble. They focused on ensuring the servo opened by fixing the code on the computer. They also added a pulley system to our third body to open the box, holding the car back in steps 14-16 to make sure the box would open and release the car so the magnet hits the lever. It is important the magnet hits the lever because the lever activates the light switch turning our lightbulb on as the last step of our machine. Colton and Jesse worked on putting a bigger lightbulb over our small lightbulb so viewers could see the light better.

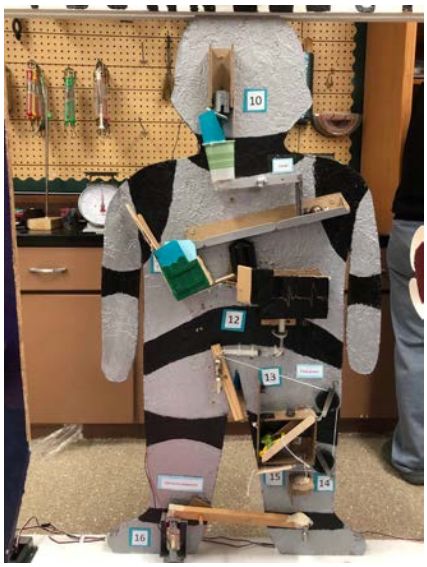


Throughout this week, we also worked on the artwork. We wanted to add more detail so everything was more cohesive and tied into the competition theme. With more detail, we could better incorporate our storyline as the extra details enhanced our machine and made the story flow better.


2. Final Machine Design Drawing/Image and Description

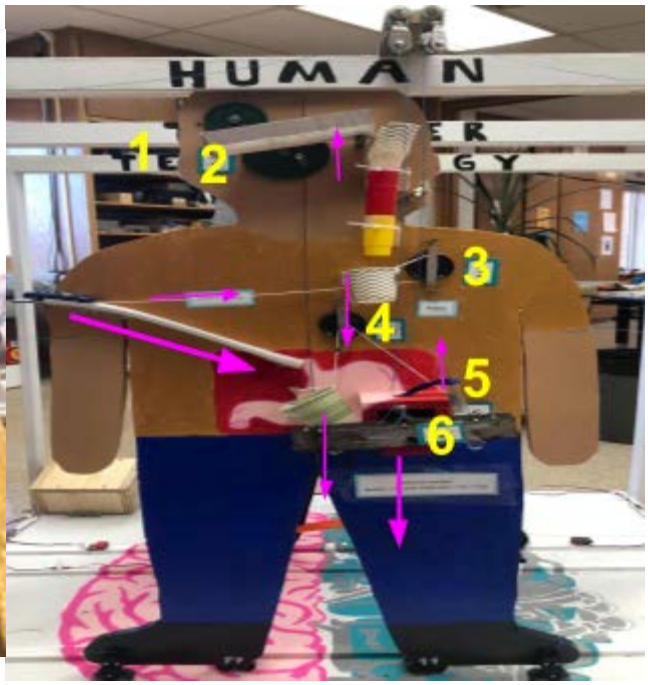
First Body

Second Body



Third Body

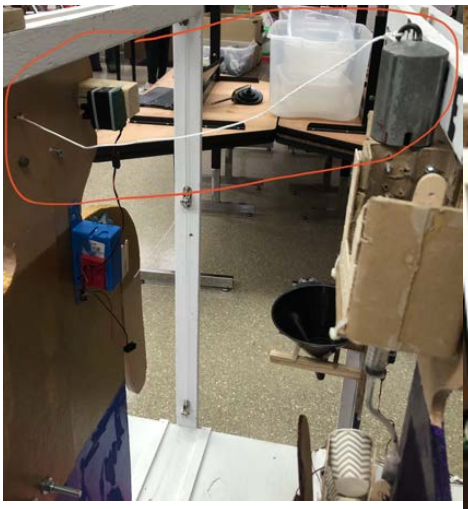
Storyline: Our rube follows human-to-tech transfer by showcasing biological and technological processes throughout all three of our bodies. The first body starts with an idea as the gears turn representing the human brain. In the body, food travels through the esophagus into the stomach. Food undergoes a chemical process called hydrolysis when digesting in the stomach. This is represented in our chemical reaction when the baking soda and vinegar react to expand our "stomach." Our second body represents blood flowing through the heart and into the rest of the body. The air in the syringe represents oxygen in the bloodstream flowing into and out of the heart. The heart is on our water wheel which has marbles in it that represent blood. The "blood" falls into the funnel activating the lever system in step 8 that represents a knee joint. The "knee joint" lifts up, releasing a car onto a ramp so it can activate a limit switch. The limit switch splits the body showing how joints represent movement in a body. Our third body shows technological processes and how they can aid humans in everyday life. When the servo turns on, it releases a weight like computers send data. The weight transfers its energy like data is transferred between computers. The marbles fall into the basket representing how data flows through wires and circuit boards. This tips a weight onto a syringe showing how data is transferred and then displayed on screens. Our rube ends with a lightbulb turning on representing new ideas. This shows a full circle moment between humans using their brains and the help of technology to think of new ideas.

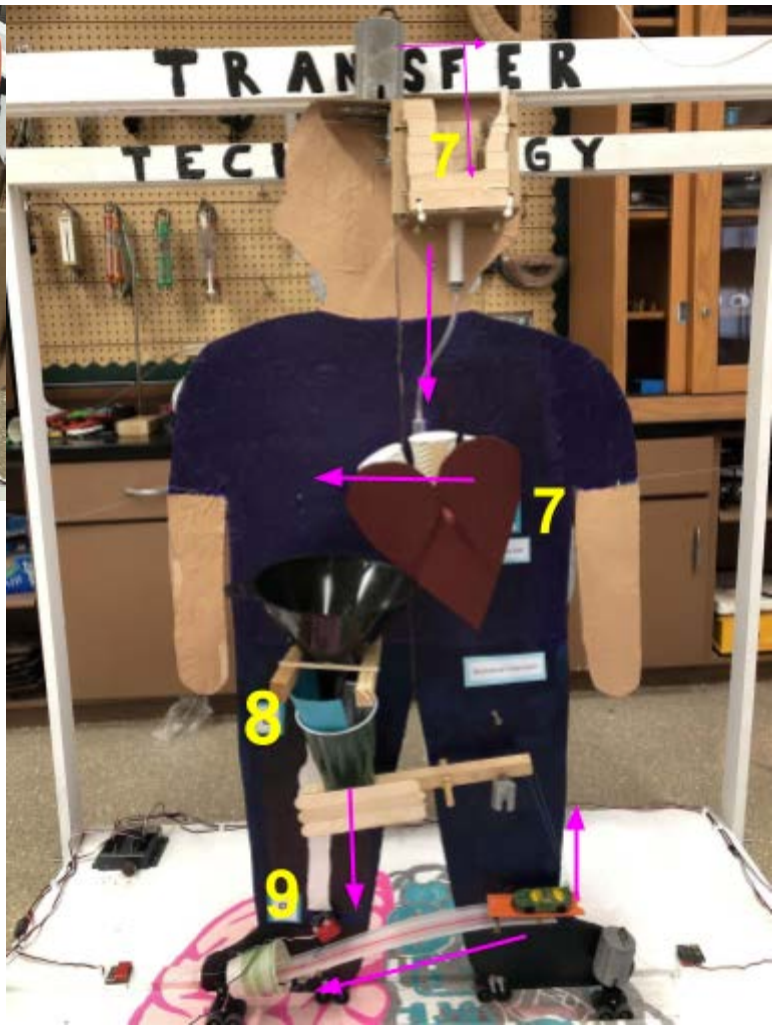


***Note: pink arrows show the flow of energy**

First Body

Step 1 starts our rube by transferring electrical energy from a light switch to a direct current motor. The motor is run by a 9V battery in a series circuit. The motor allows the gears to turn. The gears turning lifts a track setting a marble with potential energy in motion (2). The marble drops into a cup (kinetic energy), activating a pulley system with a mechanical advantage of 1 (cup drops down while brake is pulled from underneath a car). (3). This sets the car in motion down a ramp (the car starts with potential energy and, once it's set in motion, exhibits kinetic energy). The car falls into a cup activating another pulley system with a mechanical advantage of 1 (the cup goes down, and a test tube full of vinegar is pulled up). (4). This creates a chemical reaction as the vinegar falls into a balloon full of baking soda. CO_2 gas is created (releasing chemical energy), expanding the balloon (5). The expansion of the balloon hits a weight making it fall off of a platform (the waiting weight has potential energy, and when it is knocked off of the platform, it has kinetic energy because it is put into motion) (6). The falling weight is connected to a pulley system with a mechanical advantage of 1. When the weight falls, it activates the pulley system splitting the body in half to reveal the second body.





Second Body

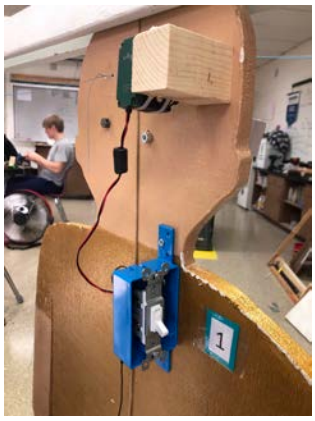
The first body splits in half. This motion allows a weight (with a string attached to the first body and the top of the weight) to be pulled into a box, landing on the plunger of a syringe (7). Air travels through the tubing into another syringe. The pressure pushes the second syringe's plunger out, hitting a platform on a water wheel (7). This represents Boyle's Law: $P_1V_1=P_2V_2$. The water wheel turns and dumps marbles into a large funnel (7). The marbles land in a cup providing enough force to push a first-class lever down on one side (input force) and bring the second-class lever up on another side (output force) (8). The lever lifting up drags a piece of cardboard up that a car is sitting on, putting the car in motion (the car has potential energy as it waits to be set into motion. Once it is set in motion, it then has kinetic energy) (9). The car goes down a ramp into a cup, activating a limit switch (9). When the limit switch is activated, it sends a signal to the motors on the side of the platform to start turning (electrical energy). The turning motors split the body in half, revealing the third body. The second body stops when limit switches on either side of the body are hit and send signals to the motors to stop turning (electrical energy).

Third Body

Two limit switches on either side of the second body have a value of 0 and send a signal to the computer when they are hit (electrical energy). When the limit switches' values are 1, the computer sends a signal to the servo and tells it to turn to the open position. The servo makes a flap holding a weight in place. The flap then opens downward, releasing the weight into a cup (10). The weight in the cup pushes one side of a lever down (input force) to set marbles in motion down a ramp (as the marbles are waiting to be released, they have potential energy, when they get released, they have kinetic energy) (10). The marbles fall into a basket (the basket sits on a hinged lever), making that side of the lever go down (input force) while the side with a weight pushes up (output force), making the weight fall onto a syringe (11). The air pushes through tubes connected to another syringe (12). The pressure from the air pushes the plunger from the second syringe out, hitting a wooden lever with small weights attached (12). The wooden lever has a string attached to it that is threaded through a pulley system with the end attached to a popsicle brace. When the wooden lever is hit, it pulls the string through the pulley system, releasing the popsicle brace and opening the door to the car launcher. This releases the car (the waiting car has potential energy and when it is set in motion it has kinetic energy) (13). The car has a magnet attached to it with a string. When the car is released, it pulls the magnet off of a platform, releasing another magnet onto a lever. The attraction between these two magnets allows them to stick together until they are pulled apart (14). The weight of both magnets stacked on top of each other pushes the lever down on one end (input force) and brings the lever up on the other end (output force). This also shows attraction between two magnets because they stick together when they are near each other (15). When the lever raises up, it flips a light switch to on, completing the circuit and turning a lightbulb on at the top of the robot (16).

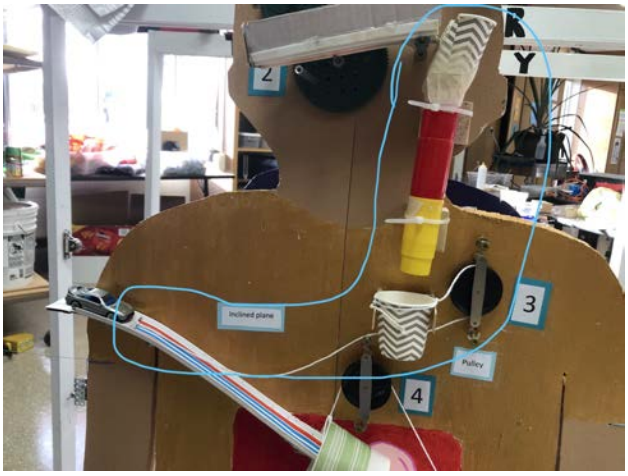
3. List of Machine Steps

1. A student starts by flipping a light switch, which turns on a motor (the motor is attached to a shaft on the back of the first gear). **Advanced Component: Electrical**

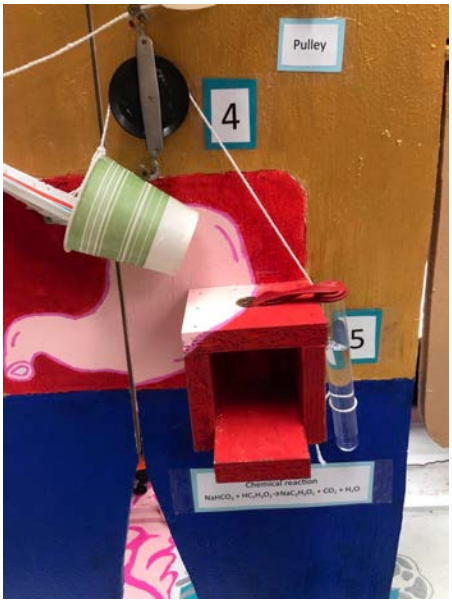


2. The motor spins the first gear in a counterclockwise motion, which in turn spins the second gear in a clockwise motion. The second gear has a shaft sticking out of it where the track rests. As the gear is turning, the peg turns and lifts the track up, allowing a marble to fall into a cup. **Advanced Components: Electrical, Mechanical**

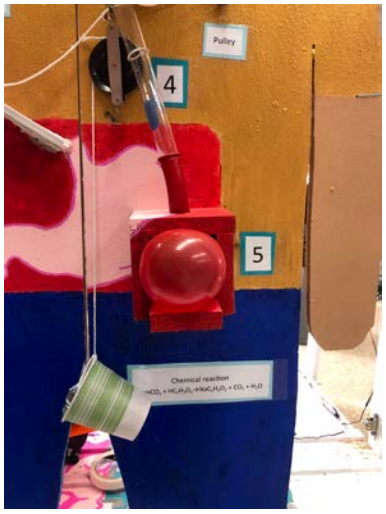
3. The marble falls down a cup attached to a tube into another cup. This cup is attached to a pulley system. One end of the pulley system is the cup, while the other end is a piece of cardboard that acts as a brake for our car. When the marble falls into the cup, it pulls the cup down and the brake out from underneath the car.
   Advanced Component: Mechanical



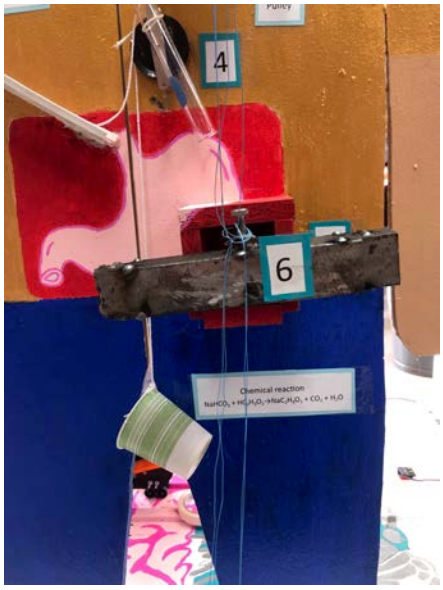
4. The car runs down the track it's sitting on and into a cup. This cup is attached to another pulley system. One end of the pulley system is a cup, while the other end is a test tube filled with vinegar attached to a balloon. When the car falls into the cup, the test tube is lifted up, allowing the vinegar to fall into the balloon. **Advanced Component: Mechanical**



5. The balloon is filled with baking soda, so when the vinegar falls into the balloon, the two materials mix and create a **chemical reaction** that expands the balloon. The reaction between the vinegar and baking soda creates carbon dioxide; this gas expands the balloon. The expanding balloon hits a 1.285 kg mass, which is attached to a pulley system. **Advanced Component: Chemical, Mechanical**



6. The falling 1.285 kg mass pulls the first body apart. As the first body is splitting, a string attached to the back, right side of the body is also attached to a 1kg mass on the second body. The string pulls the mass onto the syringe as the first body splits.



7. The 1 kg mass falls on top of a syringe pushing air through the syringe into another syringe. The air allows the second syringe's plunger to push out due to the increase in volume and decrease in pressure (closed system). The plunger pushes on a platform connected to a water wheel. This rotates the water wheel and allows marbles from three cups to be dumped into a funnel. **Advanced Component: Fluid Power, Mechanical**



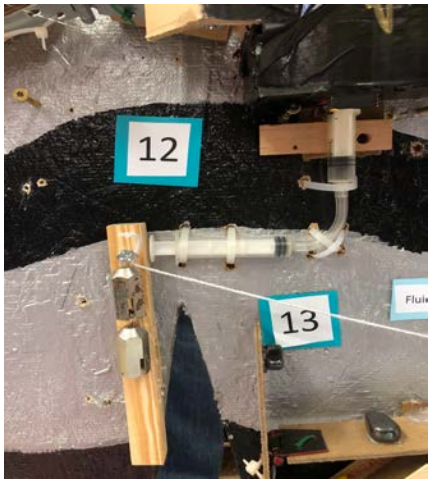
8. The marbles fall through a funnel into a plastic cup. The cup fills with marbles pushing on another platform connected to a lever system. The lever system is raised up as the cup fills with marbles. The lever rising up releases a car down a track and into a cup. **Advanced Component: Mechanical**

9. The cup has a limit switch inside of it. When the car hits the limit switch, it starts two motors, one on each side of the body attached to strings, that pull the second body apart. The body continues to be pulled (motors continue to run) until both sides hit a limit switch, simultaneously stopping the body and motors. When the two parts of the body hit the limit switches, it tells the servo on the third body to activate. **Advanced Component: Electrical**

10. A flap on the servo rotates and releases a weight into a cup. The cup rotates a lever, releasing marbles down a ramp that fall into a basket. **Advanced Component: Electrical, Mechanical**

11. The basket is attached to a lever system. When the marbles fall into the basket, the lever lowers the basket, knocking a weight off of a platform. **Advanced Component: Mechanical**

12. The weight falls and pushes down on a syringe, which pushes air through the tubing into another syringe. This allows the plunger of the second syringe to push out and hit a wooden lever with small weights attached to it. **Advanced Component: Fluid Power**

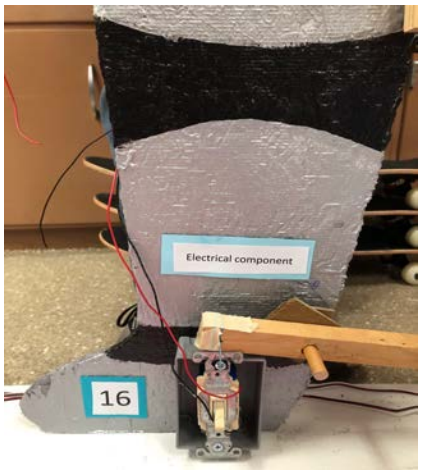


13. The lever has a string attached to it which is attached to a pulley system. As the lever is turned, the string turns against the pulleys. The end of the string is attached to a popsicle brace that is holding the door of our car launcher shut. When the string is pulled, the popsicle brace falls down, opening the door and releasing the car. The car has a magnet attached to it by a string. The magnet sits on a platform beneath the car. **Advanced Component: Mechanical**

14. The magnet is sitting on a platform, holding another magnet up using its magnetic field. When the car slides down the ramp, it pulls the magnet off the platform, releasing the second magnet.

15. The second magnet drops onto another magnet, which is attached to a lever. The weight and force of those two magnets rotate the lever. The rotating lever pulls up on a light switch. **Advanced Component: Mechanical**

16. The light switch completes the electrical circuit between the battery and the lightbulb. When the circuit is completed, the lightbulb lights up. **Advanced Component: Electrical**



4. Cost of Machine and Percent of Recycled Materials Used

Item	**Quantity**	**Origin**	**Cost**
Paint	4 colors	*Purchased*	$11.15
Paint	7 colors	Repurposed	$0.00
Primer	1	Repurposed	$0.00
Bolts	23	Repurposed	$0.00
Rollers	8	Repurposed	$0.00
Lightswitch	2	Repurposed	$0.00
Cups	9	Repurposed	$0.00
Syringes	4	Repurposed	$0.00
Balloon	1	Repurposed	$0.00
Test Tube	1	Repurposed	$0.00
Popsicle Sticks	36	Repurposed	$0.00
Pulleys	4	Repurposed	$0.00
Screws	70+	Repurposed	$0.00
Car	3	Repurposed	$0.00
Gears	2	Repurposed	$0.00
Track	3	Repurposed	$0.00
Plastic Tubes	3	Repurposed	$0.00
Zipties	20+	Repurposed	$0.00
Limit Switch	3	Repurposed	$0.00
VEX 2 Wire 393 Motor	2	Repurposed	$0.00
Servo	1	Repurposed	$0.00
Washers	9	Repurposed	$0.00

Magnets	5	Repurposed	$0.00
Hinge	1	Repurposed	$0.00
Weight	5	Repurposed	$0.00
Servo	1	Repurposed	$0.00
Plastic Bottle	1	Recycled	$0.00
Lightbulb	1	Repurposed	$0.00
Vinegar	20 mL (x10)	*Purchased*	≅ $0.30
Baking Soda	10 g (x10)	*Purchased*	≅ $0.20
Rubber Bands	5	Repurposed	$0.00
9V Batteries	2	Repurposed	$0.00
Salt	20 g	Repurposed	$0.00
Spray Paint	3 coats	Repurposed	$0.00

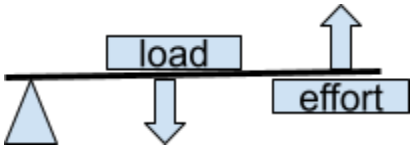
Total Machine Cost: ≅ **$11.65**
Percent Recycled: ≅ **235/241 97.5%**

5. Applied STEM Processes

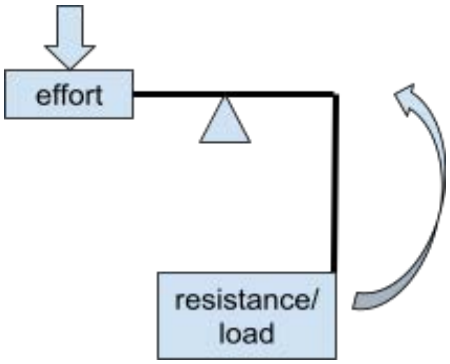
Mechanical-

Lever- (Steps: 1, 8, 10, 11, 13, 15, 16)

Our first lever is in **step #1** on the first body of our machine. A second-class lever is defined as a fulcrum on one end, force being applied at the other end, and the load in the middle of both points (*Types of lever*, n.d.). After the light switch starts the gears, it creates a force effort pushing on the opposite end of the fulcrum. This results in the load falling into a cup as the lever continues to tip.



Our next lever is in the second person of our machine, **step #8**. It is classified as a first-class lever. A first-class lever is when the fulcrum is in the middle of the load and the force effort (*Types of lever*, n.d.). This lever is a first-class lever because as a catheter bag fills, it causes the effort to push the one side down. The other side, which contains the load, allows resistance as it turns on the fulcrum in the middle.



Pulley- (Steps: 3, 4, 6)

Pulleys make many appearances throughout our Rube Goldberg machine. Pulleys are similar to levers; they both rely on mechanical advantage (*Powerful pulleys*, 2021). Our pulleys are all fixed pulleys: the wheel is attached to one spot and can't be moved, and the string moves along the groove of the wheel (*Powerful pulleys*, 2021).

Mechanical Advantage=Load/Effort

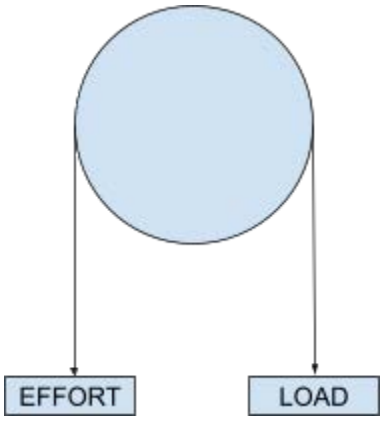
Side where string is being pulled=Effort

Side where weight is being lifted=Load

Mechanical Advantage of a pulley=number of ropes supporting the load

Our pulleys all have a mechanical advantage of 1. They have a mechanical advantage of 1 because it doesn't increase the input force, it just changes direction.

*The picture to the right shows how our pulley system works



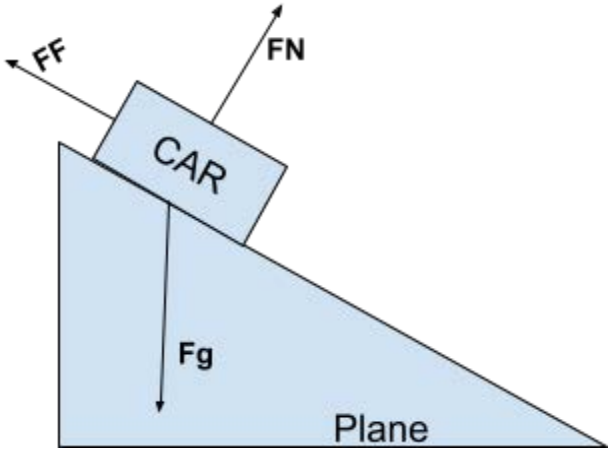
<u>Wheel and Axle-</u> (Steps: 2, 7)

The gears in our first step resemble a wheel and axle. The gears are round disks with a rod in the middle resembling an axle (*Wheel and axle*, n.d.). The effort is applied on the axle from the motor, making it turn. Then, the resistance is placed on the wheel as it continues to lift the track.

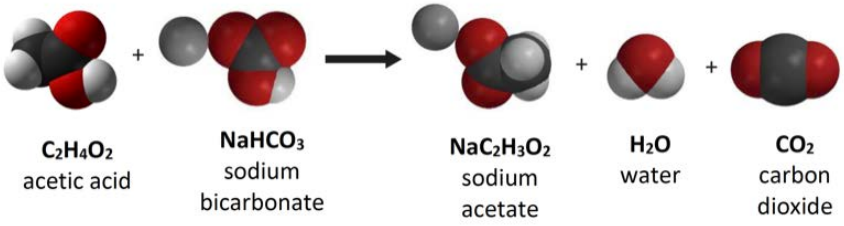
Another wheel and axle in our machine are the rollers on the bottom of the people in our machines. The input force comes from the pulley system, which makes them take action. The output force is the wheels starting to roll in opposite directions (McCabe, n.d.).

<u>Inclined Plane-</u> (Steps: 3, 4, 9, 10)

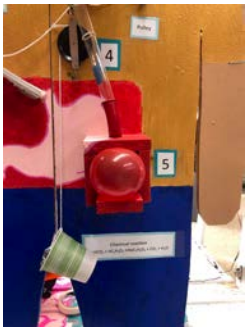
On our first body, we have an inclined plane: the track the car goes down. The diagram below shows a Free Body Diagram (FBD) of the inclined plane. An FBD shows the direction of all forces acting upon an object. The FBD shows how the car moves down the ramp and the forces acting on the car. F_F stands for Force Friction, F_N stands for Force Normal, and F_g stands for Force gravity.



Chemical Reaction-



(*Baking soda and vinegar*, n.d.)

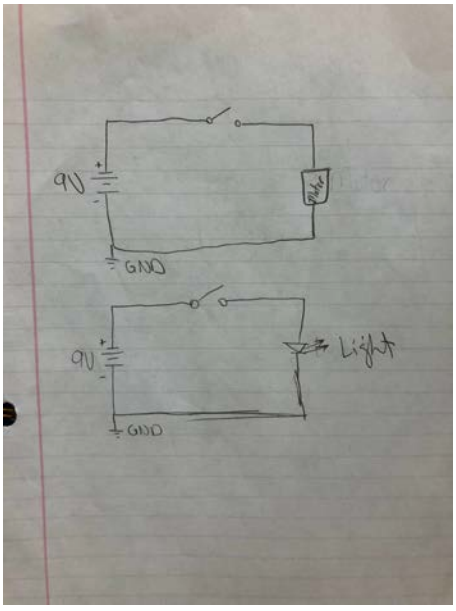


Step 5:
For our chemical reaction advanced component, we used the reaction of sodium bicarbonate and acetic acid (baking soda and vinegar). The baking soda is loaded in a balloon and a test tube is attached and dumps the vinegar into the balloon. When the reactants are combined together, they produce carbon dioxide gas as one of the products leading to the balloon inflating.

Electrical-

<u>Light Switch-</u> (Steps: 1, 16)

Both light switches are series circuits. Series circuits are designed for a one-way path end-to-end flow for electrical current. When part of it is removed or not working, it causes the whole circuit to be unable to pass the electrical current (*Series circuits*, n.d.).



The electricity is stored in the battery and passes through the circuit. The switch limits the ability of the electricity to move. If the switch is open, the circuit is not complete, and electricity won't flow. When it is closed, the electricity flows through the motor or light. The light turns on, and the motor will turn. Once the electricity is used, it becomes negative and travels back to the battery.

```
task main()
{
  while (1==1)                                          //This program will run forever
  {
    if (SensorValue(lsb)==1)                            //If the limit switch on the body is pressed
    {
      startMotor(rightmotor,127);                       // the motors will turn
      startMotor(leftmotor,127);                        // the motors will turn
    }
    if (SensorValue(lsl) == 1)                          // if the limit switch on the left side is pressed
    {
      stopMotor(leftmotor);                             // the motor on the left side will stop
    }
    if (SensorValue(lsr) == 1)                          // if the limit switch on the right side is pressed
    {
      stopMotor(rightmotor);                            // the right motor stops turning
    }
    if (SensorValue(lsl) == 1 && SensorValue(lsr)==1)   // if both limit switches on the platform are pressed
    {
      setServo(servo,-126);                               // the servo will turn -90
      wait(10);                                         // it waits ten seconds
      setServo(servo,0);                                // the servo will turn to 0
    }
  }
}
```

Code: Colton used RobotC to code the program for our motors, limit switches, and servo. He sent the program to our brain, which is attached to our rube platform.

Motors- (Steps: 1, 2, 9, 10)

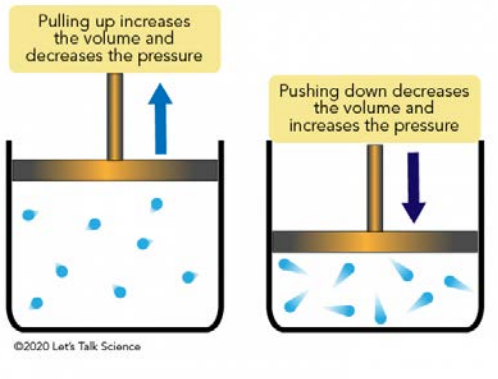
Our rube uses two VEX 2-wire 393 motors. These motors are used to spin gears (body 1) and run limit switches (body 2). The VEX 2-wire motors are 7.2 volts and are programmed to run when a light switch is flipped, and a limit switch is hit, respectively (*393 motors*, n.d.). They are wired to a central brain where the information to run the motors is stored. Our rube also uses one servo motor, which starts our third body by opening a flap to allow bolts and nuts to fall into a cup.

Limit Switches- (Step: 9)

We have three limit switches on our machine. They are used to stop the electrical flow from the brain. When a limit switch is pressed down, it allows the electrical current to flow in a completed circuit and gives the brain a readout of 1. We are using it in the Rube to tell our motors when to turn on and off. When the limit switch on the second body gives a signal of 1, the brain sends electricity to the motors. The limit switches on the platform are used to stop the motor. When the limit switches=1, the brain stops sending electricity to the motors; it sends electricity to the servo on the third body.

Fluid Power-

Boyle's Law: $P_1V_1=P_2V_2$

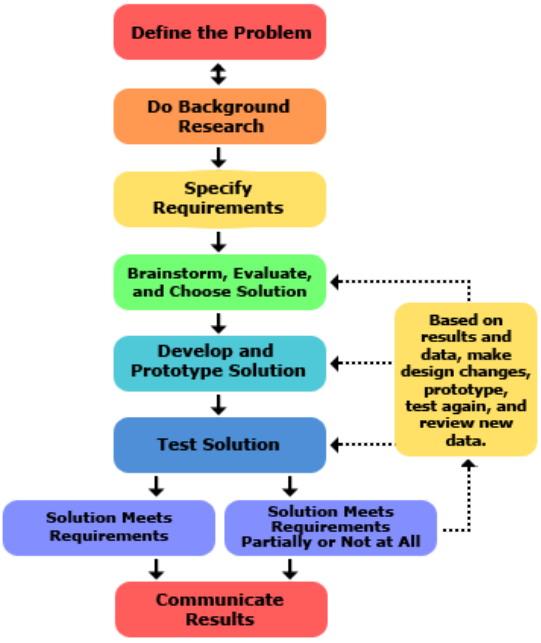


(*Backgrounders Boyle's law*, 2020)

Boyle's Law is a gas law (describes fluid as a gas) that states the pressure and volume of a gas have an inverse relationship (*Boyle's law*, 2024).
Fluid power: The use of fluids under pressure to generate, control, and transmit power (*What is fluid*, n.d.). A fluid is a liquid or gas that continuously flows under pressure (*Boyle's law*, 2024). In our rube's case, our fluid is air.

Syringes- (Steps: 7, 12)
Our rube uses fluid power through syringes. We have two syringe systems on our rube (one on the second body and one on the third body). In both cases, a weight presses down on the plunger of the first syringe (decreasing the volume and increasing the pressure), pushing air through the tube and into a second syringe. The air fills the chamber (increasing the volume and decreasing the pressure) and pushes the plunger out of the second syringe to trigger our next step. The same amount of pressure pushed out of the first syringe is pushed out of the second syringe (*Boyle's law*, 2024).

Engineering Design Process-



The engineering design process is a specific set of steps engineers use to solve a problem. We used this process multiple times in our rube when steps would go wrong, and we would have to make adjustments in order to make the steps work. One of the greatest examples of this is our water wheel (steps 7 and 8). Our first idea of filling cups with water that would fall into a funnel and fill a catheter up seemed like a great idea until water kept spilling everywhere. At first, we tried to solve the problem by closing the holes in the cups with hot glue. This seemed to work for a couple of run-throughs, but eventually, more holes appeared in the cups, and more water leaked. Another issue we had was water splashing outside of the cup "backboard" and getting into our cup with the limit switch. We decided this was dangerous due to the electrical components. To solve the problem, we decided to use red marbles to represent blood and use a bigger funnel so the marbles could fall through. This got rid of the water leakage issue and allowed us to keep the general idea of our step intact. Throughout our design process we've had to make many changes to our rube to make sure it runs smoothly and efficiently. Our third body needed the most changes after our first contest because it wasn't running reliably (sometimes it would work and other times it wouldn't). Our biggest issue was in steps 13-15 because our car wasn't falling on our lever every time. Originally we had tape holding the door shut of our car launcher but it would either open before it was supposed to or it wouldn't open at all. In order to change this, several team members worked together to come up with a new design. After brainstorming ideas the general consensus was to use a pulley system to open the door of the car launcher. This allowed the last steps of our rube to effectively run every time and made our machine more reliable (*Engineering design process*, n.d.).

6. Reflection

One of the biggest challenges we faced as a group was learning how to put our ideas into action. Group members expressed creativity in their ideas for steps but lacked the ability to build the steps the way they envisioned. Jesse, Colton, and Myla knew how to build and create steps based on others' ideas. They helped put the ideas into action by coming up with creative solutions to design the steps other members thought of.

A small challenge we faced right away was coming up with the base design of our rube (what we wanted to put the steps on). We established one design (one singular body) and then ended up changing the whole design (three bodies). Changing the whole design worked in our favor because it allowed us to have more surface area to work with, but it set us back on building due to the changes. Now, we had three bodies to build and paint instead of just one. We came in multiple days outside of school to catch up to ensure we would finish our build in time.

Another challenge we faced was coming up with enough steps for each body. We originally decided to use steps on each body that represented a part of the theme (human, transfer, and technology). These were the gears (like your brain thinking), the chemical reaction in the stomach, and the fluid power around the heart to show oxygen moving through the heart. After establishing these "main" steps, we had to think of connecting steps, which ended up taking a while. This also prolonged our building process as we weren't sure what steps would be where. To solve this challenge, we assigned group members to each body in order to separate the responsibilities and make the task seem smaller and less overwhelming. This proved to be helpful as ideas started forming, and connecting steps were added to each body design.

Our group found major success in completing a body. When all of the steps were added to the body, and a run-through of the body proved to be successful, we felt excited and ready to tackle finishing the other bodies. After the first body was finished, we had renewed energy and quickly worked to finish the second and third bodies. With this success came another challenge: figuring out how to connect the first body to the second body and the second body to the third body. Steps 6 and 9 demonstrate the connection between the bodies.

Working on the rube was a great opportunity for every team member. We learned valuable communication and teamwork skills that will benefit us in future careers. Learning how to not only come up with ideas but to take those ideas and put them into action boosted our confidence in our ability to achieve a challenging task. Jesse, Colton, and Myla are going to college for engineering, and this opportunity has been especially important to them as they have gotten to showcase their engineering skills. Ava, Hillary, Alivia, and Joseph are all going into some aspect of the medical field. Learning how technology benefits humans has helped them learn more about technology in medical fields, and we were able to take some of their medical knowledge and incorporate that into our rube. Claire wants to go into the science field (Marine Science), so learning more about advanced components and how they are used in everyday life was valuable knowledge for her. The designing, building, and adapting processes proved to provide valuable knowledge and skills that team members will apply in their future studies.

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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 except as outlined below. 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. If using sponsor logos, maintain their brand colors and design as best as possible. It is understandable that slight color variation may result due to media used. Teams are permitted to use the EMDC logo and theme graphics creatively and do not need to adhere to specific colors or arrangement of components.

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