Williams Bay
EMDC Journal

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Special Thanks to Alora Rath for bringing an artistic touch to the build!

Group objective: Engineer and build a functional system that resembles the anatomy of the human body.

Criteria and Constraints:

- Must include Mechanical, Electrical, Fluid, and a Chemical Reaction.
- Must be repeatable
- No more than 5’x5’x5’
- 15-20 steps
- Must be safe
- No more than 2-minute run time.

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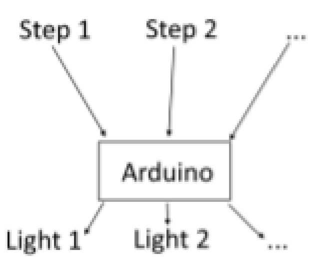
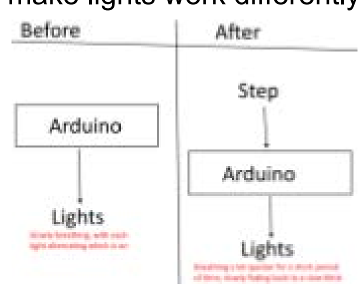
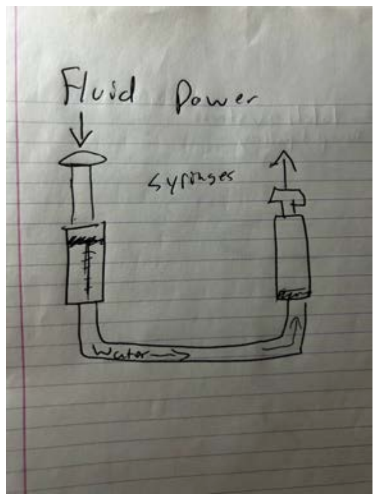
Planned Machine Design Sketch and Description

		
2/22/2024 Today was our first official meeting and we went over our general design and began mocking up our first few steps.	We created and mounted a metal hammer for the beginning of our mechanical step.	2/23/2024 We finished mounting the hammer and turned the axle that it rides on. This is the first prototype for the initial mechanical step.
2/26/2024 Began work on the powered fan for our fluid step. Finished the stand and started the hub. Created first idea to use an arduino for some light effects.  	2/27/2024 Still working on the fluid step. We drilled the holes in the hub to mount the blades. The motor is mounted within the stand and it has been mounted to our base. We had to remake the motor mount and hub as they did not fit the motor and were therefore not concentric. We have finished the leg-kicking mechanism and will work further on touch ups. I tested	2/28/2024 Today we created the smaller windmill that takes the power from the moving air of the larger one. Changed idea for arduino to make lights work differently. 

<table>
<tr><td></td><td>the mechanism to make sure it works properly and triggers correctly.</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2/29/2024, we finished the inner detail in the hammer and rethought the windmill idea, scrapping it.</td><td>3/4/2024 Today we began our other fluid step using water pressure, it will use a threaded rod to press on a syringe and create a pressure difference.

</td><td>3/5/2024 Today we finished the hydraulic system of syringes and tubing. We tested the pressure with water mixed with red food coloring to resemble blood.
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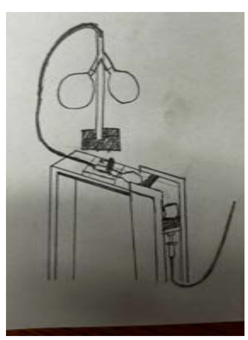
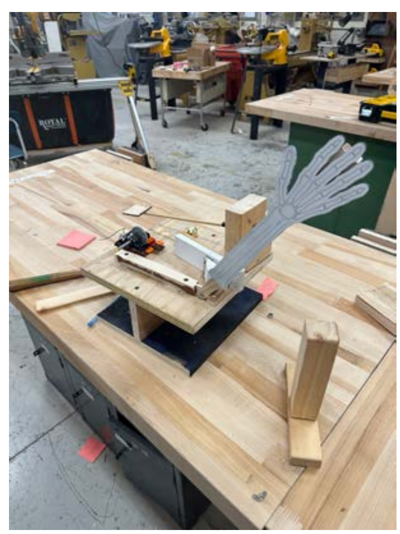
<tr><td colspan="3">   </td></tr>
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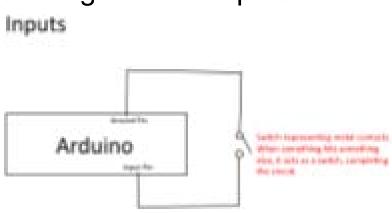
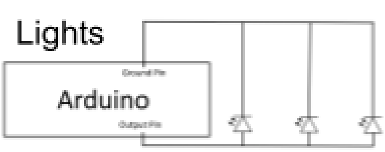
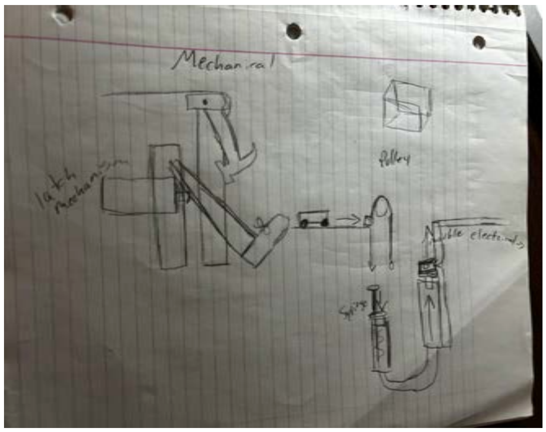
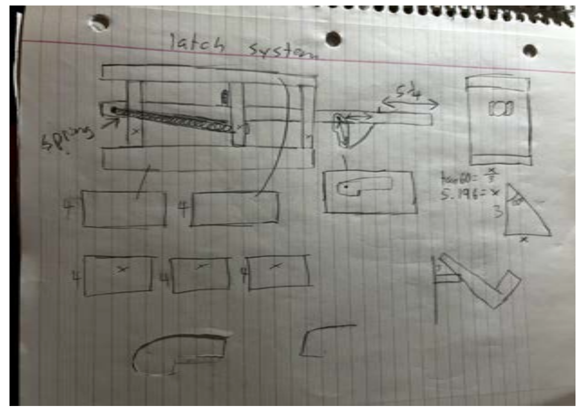
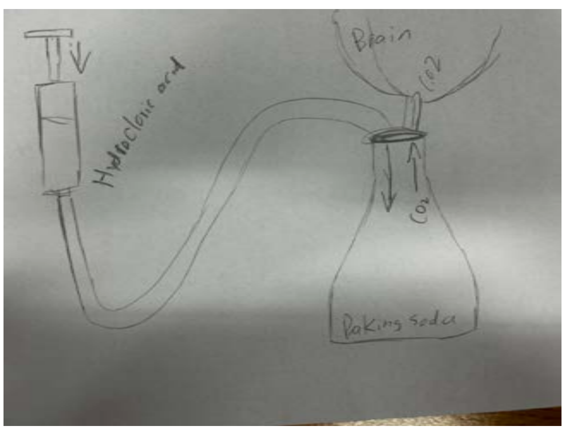
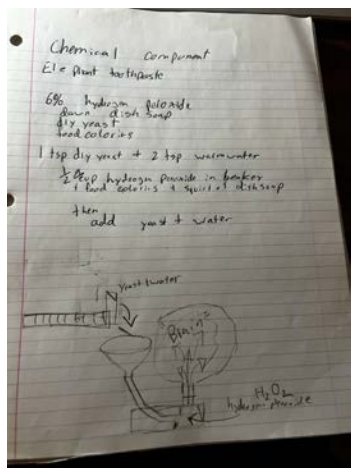
3/6/2024 Today we completed quite a few of our systems. The first electric system is now complete. The gearbox is functioning and has enough pull force. Tomorrow we will elevate the platform to mount our power system underneath it. Finished programming the arduino and can start wiring, starting with the inputs.  	3/7/2024 Today we painted the entire base and most of the individual systems. We settled on a design for our system that opens the airway for the respiratory system, including but not limited to: a 6-volt motor, a Lego gearbox, a winch attachment, and a silhouette of a human arm using its bicep and a pulley system to pull the arm down and activate the next step; rotate the lever down and open the ball valve attached to the fulcrum of the lever. 	3/8/2024 Today we completed all systems of our machine. On Monday we will match everything up, check the reliability of the machine, take the final machine picture, and touch up any pain. Throughout the rest of next week we will run our machine many times, this is to ensure the reliability of the systems and how they interact with each other, just like the actual human body. We will create a graph or journal entry for the full test runs that we are able to do before our cutoff. We are expecting for a failure rate of under 1:15, zero leaks in the respiratory and cardiovascular system, and no shorts in any of the electrical components.
3/11/2024 Today the wiring for the inputs has been finished and the wiring for the lights have been started.  	3/12 Wiring for lights is still being worked on. Difficult to attach lights.	3/15 Day of competition, still attempting wiring for lights. Problem with arduino; we decide to scratch lights. At competition part of fluid system breaks.
5/8/24 We decide to fix wiring, defined problem with arduino and are now fully working.		

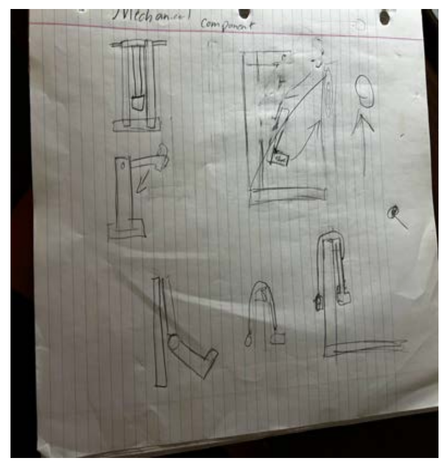
Early Sketches

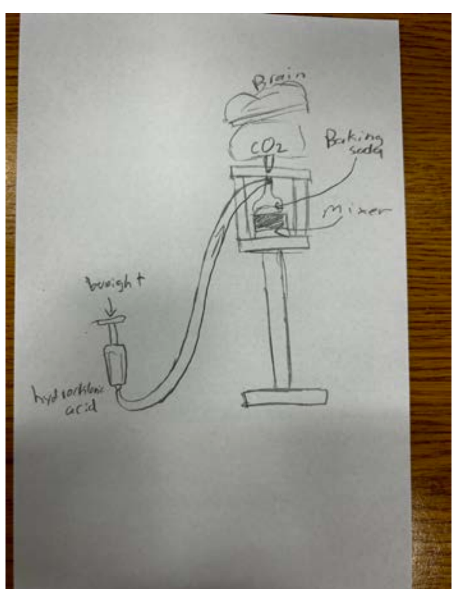


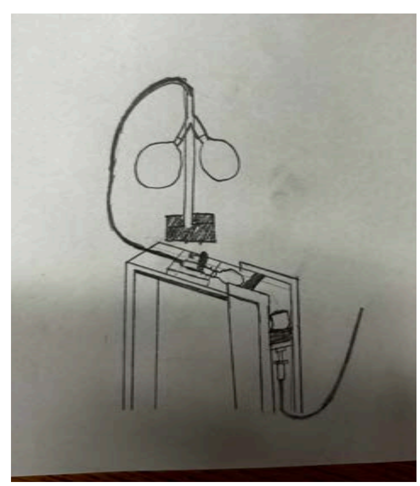




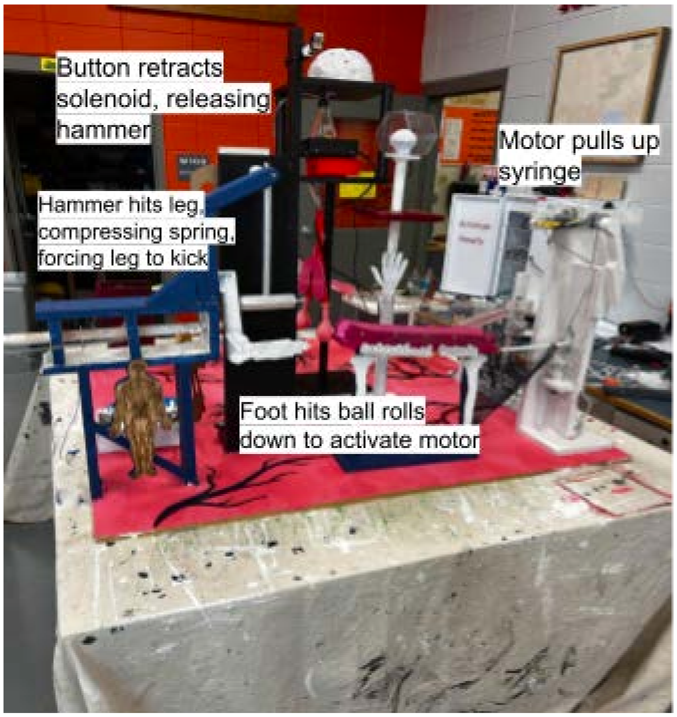


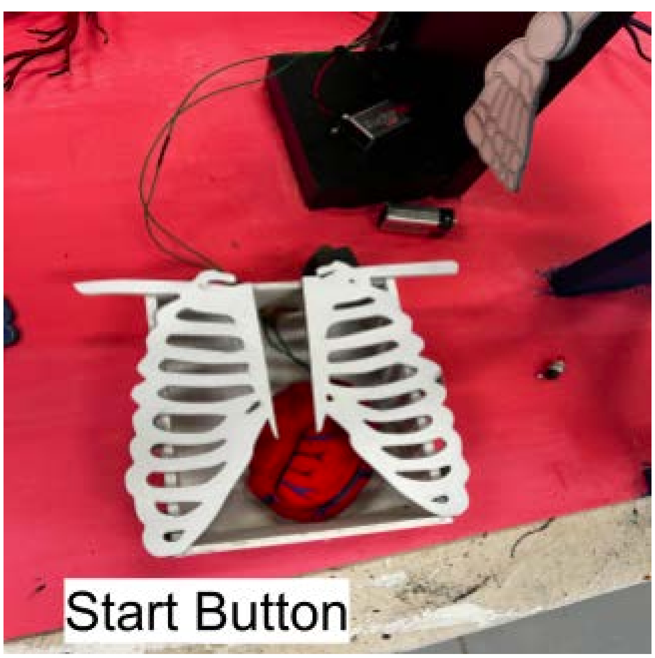


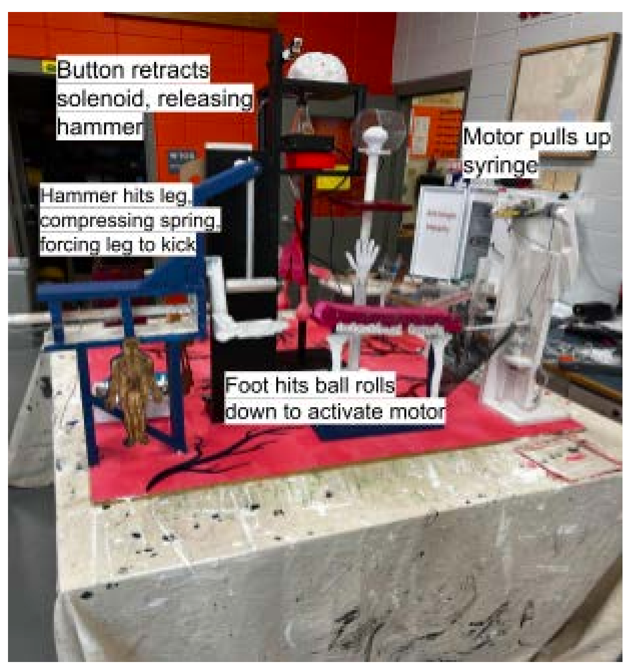


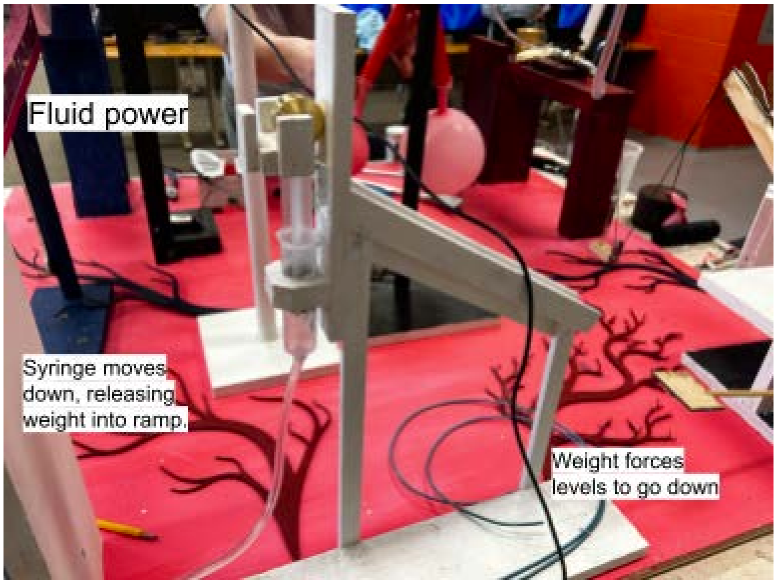


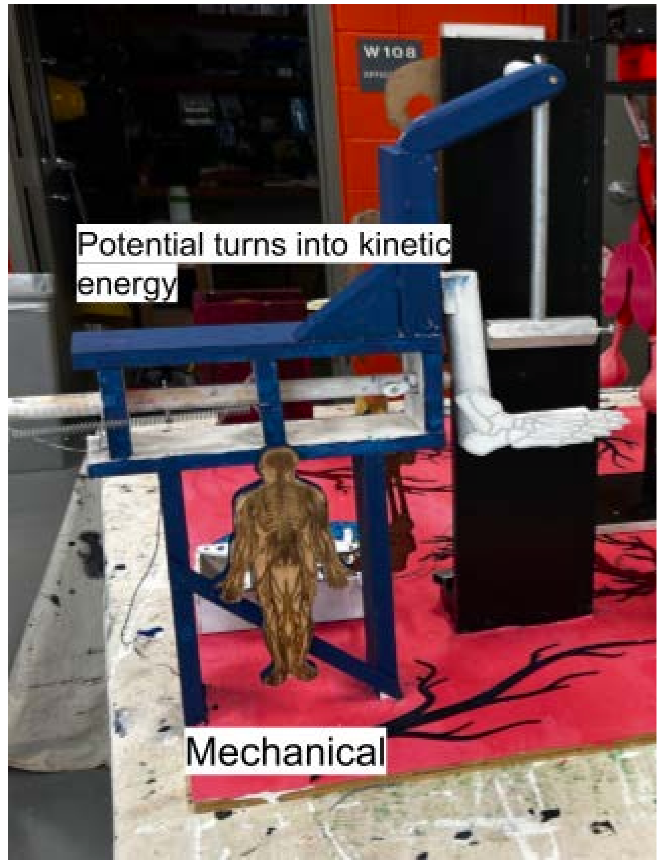
Final Machine Design Drawing/ Image and Description

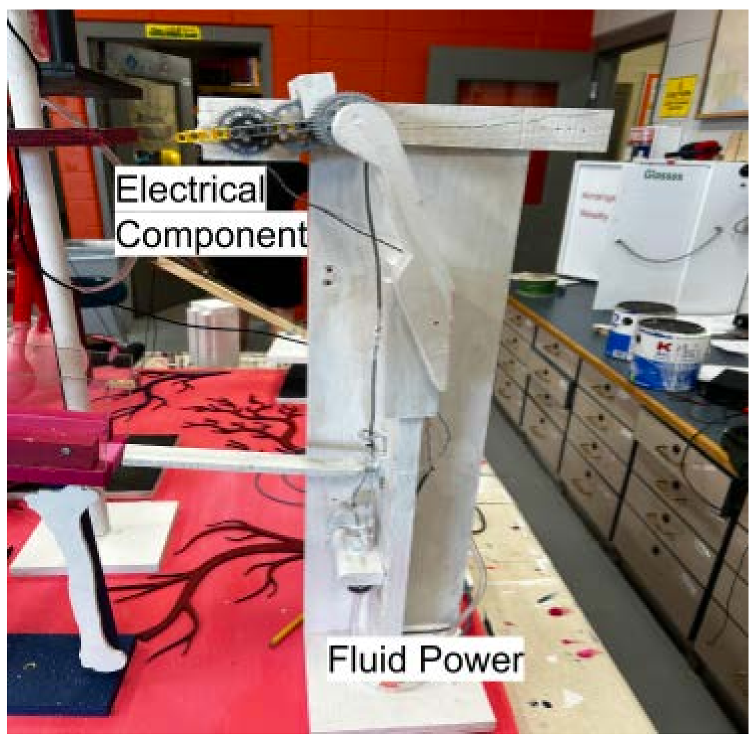







Fluid power
Syringe moves down, releasing weight into ramp.
Weight forces levels to go down


Potential turns into kinetic energy
Mechanical


Electrical Component
Fluid Power

Machine Steps

1. The operator hits a button, which in turn,
2. Activates a solenoid, which then releases the hammer
3. The hammer then hits the knee activating the reflexive/nervous system
4. The reflex system pushes the leg into a ball
5. The ball rolls down the ramp
6. The ball hits a lever and activates a motor
7. The motor turns on and activates the hydraulic system
8. The hydraulic system pulls up a syringe releasing a ball
9. The ball rolls down a ramp and hits a lever activating a motor for the muscular system.
10. The motor pulls a hand back which pulls a string and also shuts off the motor
11. The string pulls down a lever which opens a valve activating the respiratory system
12. The valve releases the pressure of two balloons into one balloon.
13. The singular balloon inflates and knocks a brass cylinder onto a platform.
14. The platform drops pushing the syringe down
15. The syringe pushes vinegar through a tube and into a bottle containing baking soda
16. The vinegar and baking soda react to blow up a balloon.
17. Throughout the whole process, there are lights that interact.
18. A lightbulb turns on at the end, representing activity in the brain

Cost of Machine and Amount of Recycled Materials Used

Item	Quantity	Origin (Borrowed, repurposed, or purchased, or made)	Cost
4’x4’ plywood	1	Repurposed	N/A
Solenoid (12v)	1	Purchased	$7.49
Arduino board	1	Borrowed	N/A
Wire 16, 26 AWG	?	Repurposed	N/A
Motor (6v)	2	Repurposed	N/A
Syringe (Fluid)	3	Repurposed	N/A
Tubing	2	Repurposed	N/A
Foam Heart (pack of 3)	1	Purchased	$8.99
Plastic Brain	1	Purchased	$9.98
Pink Balloons	2	Purchased	$2.12
Pink Paint	1	Purchased	$0.62/oz
Navy Paint	1	Purchased	$0.62/oz
Red Paint	1	Purchased	$0.62/oz
Hammer	1	Made	N/A
Dowel Rods		Repurposed	N/A
Spring	1	Repurposed	N/A
Air compressor	1	Borrowed	N/A
Valve	1	Borrowed	N/A

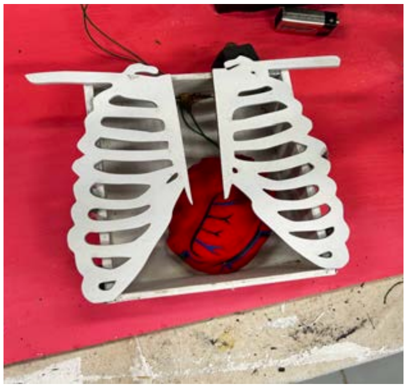
Variable power supply (1.2-)	1	Borrowed	N/A
USb Light bulb	1	Purchased	16.98
Hexagonal plastic container	1	Purchased	12.49
Scrap wood	All	Recycled	N/A

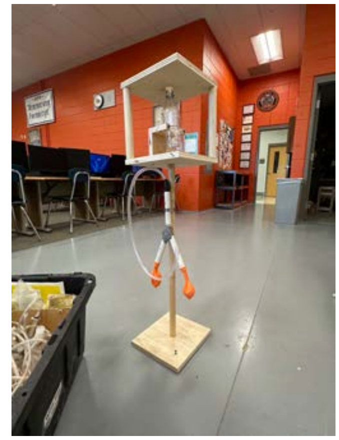
Total Machine Cost: $64.87

Statement of Recycled and Repurposed Pieces:

As complicated and tech-heavy as our build may seem, very few pieces were actually purchased for the purpose of the EMDC. Inside the wood shop, there are several scrap bins, in which all the excess wood from shop classes is tossed into. After designing the build, we went through the scrap bins and found usable pieces of wood that would be perfect for us. After scavenging for a couple days, we were finally able to start production. All the electrical components have been repurposed for this project. The Arduino kit is mostly used for educational purposes, but we converted it for our lights; the motors are usually only used for classroom purposes as well. The wiring we used for the motors and the lights was all repurposed. We ended up cutting open some old cables and transforming them for our own use.

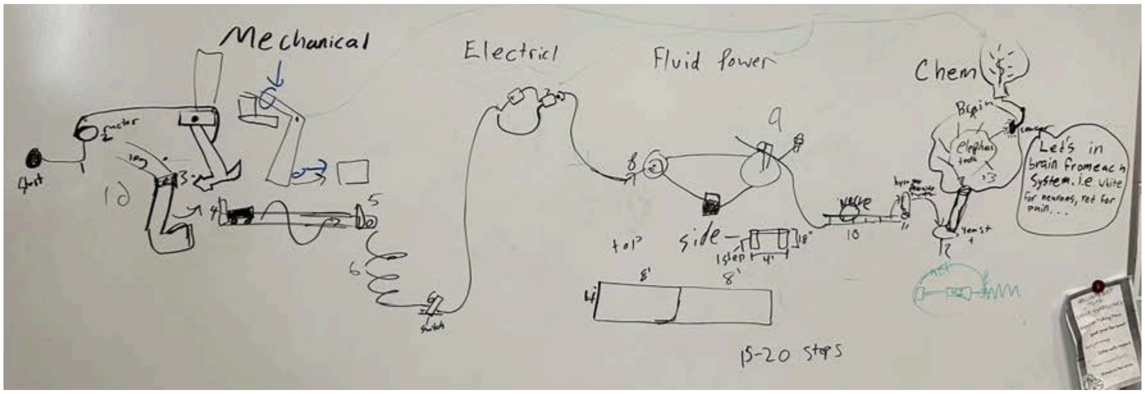
Applied STEM Processes





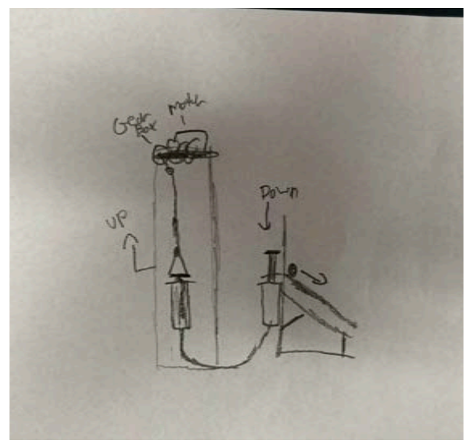
- Biology: We used body systems as an inspiration for the build, including veins and arteries, the digestive system (or muscular system), the respiratory system in how the lungs expand and contract with the balloons, the musculoskeletal system with ligaments/tendons as they're pulling the string that is connected to a lever through a pulley system, and the nervous system running throughout with firing neurons represented through our lights.

- Tech Ed Machines: As Tech Ed students, we were already familiar with most of the machines we used. We used the bandsaw, drill press, miter saw, laser cutter, etc.
- Physics: Force of the hammer hitting the knee forces the elastic potential in the spring to turn into kinetic. We relied on the force of gravity to allow for the ball and weight to go down the ramp.

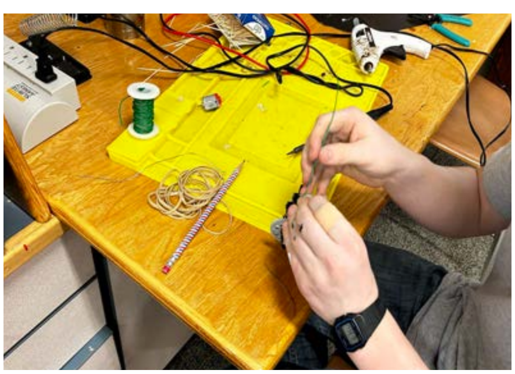


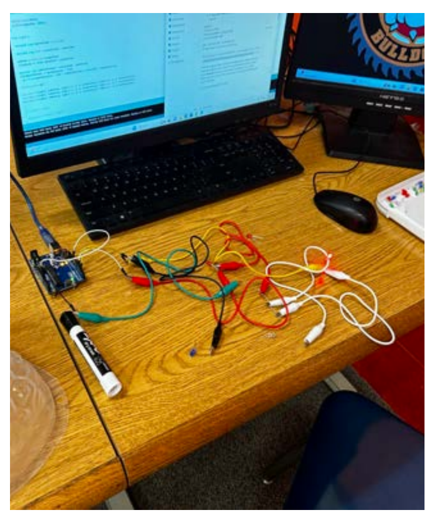
- Engineering: We researched human influences, created a concept, designed the machine, experienced trial and error, and created a solution to our problem.

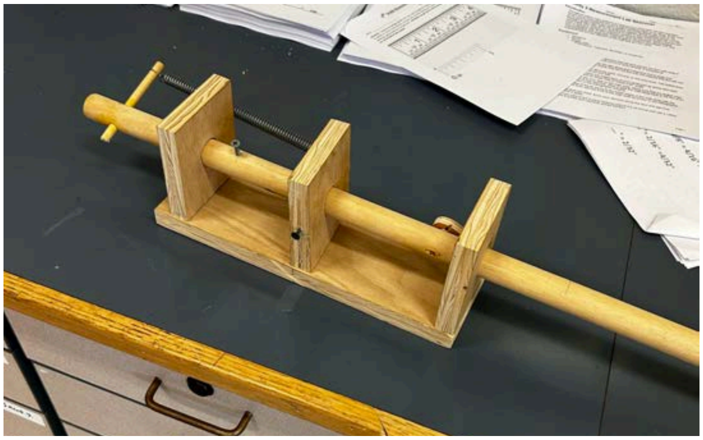
- Fluid Power: We utilized both gas and liquid for this component. The first fluid power component forces a syringe to move a weight upwards which then rolls down a ramp. The second fluid power component releases the hydraulic fluid into the flask for the chemical component.



- Electrical Power: There are many electrical components within our build. We used an Arduino kit to create a nervous system of lights that interact with the machine. We also set a start switch with the heart. There is a motor that pulls a syringe up. There is also a different motor that opens up a valve for the balloons to deflate.

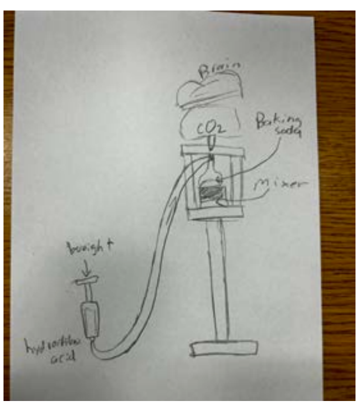






- <u>Mechanical Components</u>: There are many mechanical components throughout the build, which include springs, levers, ramps, axles, etc. However, the main mechanical component is the spring latch mechanism. As the hammer hits the leg, the spring is compressed, forcing the potential elastic energy in the spring to convert into kinetic energy; therefore, the leg kicks out.

- <u>Chemical Components</u>: Vinegar reacts with baking soda to create CO2, we harnessed this to fill up a balloon. This was a challenging step because we had to balance the ratio of vinegar and baking soda to create a strong enough reaction to fill the balloon. We moved from using a soda bottle to an erlenmeyer flask with a double-hole top and a magnet spinning inside to make sure all baking soda reacted. We also changed our vinegar to hydrochloric acid, as the vinegar was not generating enough CO2. While hydrochloric acid is more powerful, it is entirely neutralized by the baking soda in a contained setting to ensure safety. We made sure to seal the tubing to create enough pressure to blow up the bag.



Reflection

The past couple of weeks have been quite a stressful and educational journey. We had a small group of freshmen who participated last year, however, the Engineering Machine Design Contest was a new experience for most of the team. As a group, we have refined our skills and even learned some new ones. Our Rube Goldberg machine was the perfect opportunity to apply the team's woodworking, coding, soldering, and artistic skills. The lessons we have learned will prepare us for future events.

The first lesson we learned throughout this experience is how important planning is. The engineering design process exists for a good reason: it allows us to track our failures in order to find a solution. Since most of the group has impulsive tendencies, it was very difficult to slow ourselves down to think and plan. We started off by drawing some beginning and ending steps on a whiteboard to figure out what materials we needed. Our general plan throughout the process was to create the complex components separately and then find a way to connect them later.

One of our main challenges dealt with the first fluid power component: The set of syringes that lowers the weight to roll down the ramp. We thought the hoses that lead into the pipe were airtight, however after we assembled the syringes and put them into place we found tiny air bubbles in the syringes; we had a leak. After putting the system all together, we had to take it all apart just to find that little hole, and once we did, we patched it up and bled into the system again. What we learned from this challenge is that you should always check the individual parts of a system before assuming that it is going to work. There were a lot of parts that we made and moved on without testing, meaning we had to go back later to redo or fix. It took up a huge chunk of our time, what if we tested it earlier we would have been able to get more done sooner.

Another challenge that we dealt with as we built our system was the chemical reaction step. In theory it should've worked, however we failed to note the amount of reaction we would need to inflate a balloon. Our reaction did not produce enough carbon dioxide to fully inflate the balloon. So we had to think about our options, we could either modify the contents of our solution, or change the solution for a more powerful reaction. We chose the second option, change it, our first solution was vinegar and baking soda and we changed it out for hydrochloric acid and baking soda. This produced a much stronger reaction which, in turn, filled up the balloon that filled up the brain. The problems that we faced not only stopped our progress, but it took up the short time that we needed to finish our project entirely.

The final and most important challenge we faced was the time constraint. We were forced to learn the importance of time management. Our complicated build was started a bit late into the year. We designed, built, and decorated it in approximately two and a half weeks. To complicate matters further, many of us had to prepare for the ACT and attend multiple extracurriculars such as Drama Club and Math Team. We used up any study halls, class periods, lunches, and after-school time to work on our project. After tirelessly working on our project, we are proud of what we have accomplished in such a short time span. In future years, we will make sure to start several months earlier.

The EMDC has been an educational journey for all of our team members.

Bibliography

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