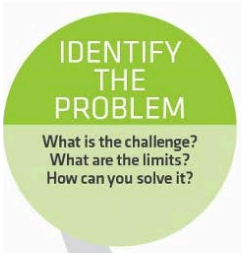
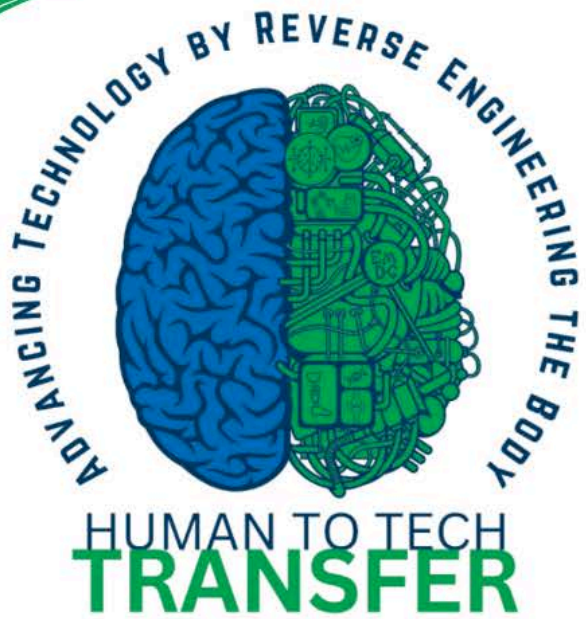
ENGINEERING MACHINE DESIGN CONTEST 2024

CHATFIELD HIGH SCHOOL

"Technology Doctors"





Theme interpretations:

- Reverse engineering the body = Skeleton needs its "parts" to become human
- Doctor's Office
  - Restore the skeleton back to life
- Use technology
  - 3D print missing body parts
  - Organ transplantation
  - Heart monitor
  - X-ray machine
  - Pulse oximeter
  - Digital patient records

TEAM ROLES

Lead Engineer -Maddie
Advanced Components Captain -Gavin
Photographer/Videographer - Ella
Artist / 3D printer- Kael
Step Chief - Andrew
Safety Officer -Brady

1. Bibliography - These are all past Rube Goldberg machine-run videos we used for ideas and inspiration.

1- https://youtu.be/3rjLPX-LcB8?si=C_yHG4DJ-LLOhbzVQN

The person in the video started off with burning a string that would release the car. Then the car would hit dominos that pushes the cup into a ball. The ball then rolls into a corner piece and hits a lever that flings a dog treat.

Our team got the idea to use dominos and a lever from this machine.

2- https://youtu.be/AAwuZM2MBJQ?si=_UKBEdl9g1z7K8bF

The team in the video pushed a pin up that released a ball. The ball then fell into a cup which released another ball that fell through a circular Plinko board. The ball went through a funnel which then started a truck. The truck hit another tractor which hit a car that released a pin that released another object which made a guy fall. The guy then released a ball that bounced down cups and went into the bucket.

Our team got the idea for a Plinko board from watching this video.

3- https://youtu.be/GGQ3xry-90s?si=WRoOAfaXRWlL3D2F

In this machine they dropped a ball down a ramp which hit a line of dominos. The dominos hit a ball into a cup, the cup hit another ball down another ramp. The ball hit another line of dominos. The dominos then hit a button.

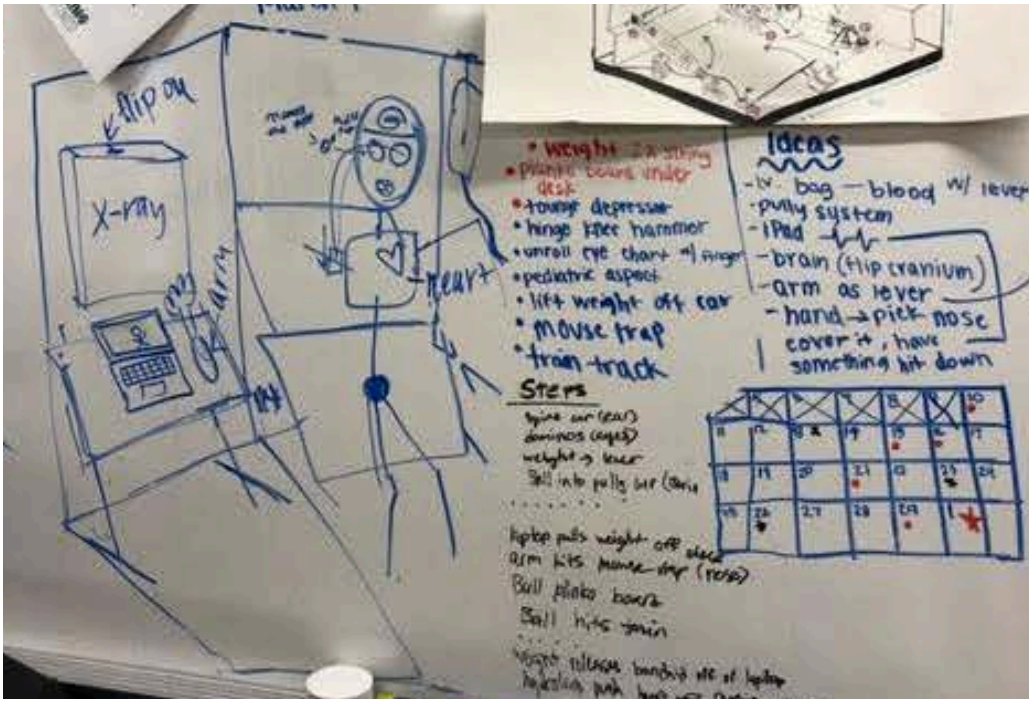
Our team got the idea to use ramps from the machine in the video.

4- https://youtu.be/PVZ-msupo1U?si=5w0P86DtrQGTptFn

This machine used a lot of books in their project. They used a lot of strings to pull the books and other objects. They used cars and tracks. They also used a lot of dominos and pulley systems.

Watching this machine, our team got the idea to use strings in our machine to hold things up or pull other things.

2. Initial Sketch and Description of Planned Machine Design



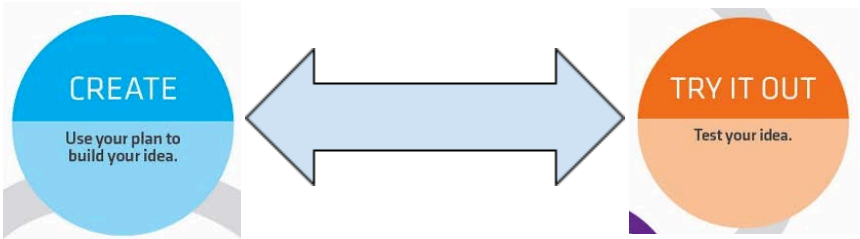
Ideas:

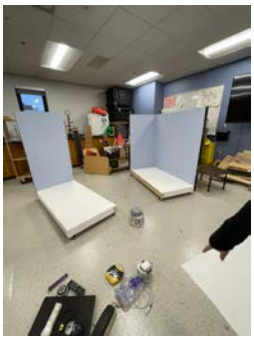
- Hand as a lever
- Lungs (chemical reaction)
- Brain (cranium closes)
- Eyes go into skull
- Turn x-ray on
- Close doctor's computer
- Use diagrams of body parts
- Heart goes into chest
- Last step = Turn on ipad with restored heart rhythm

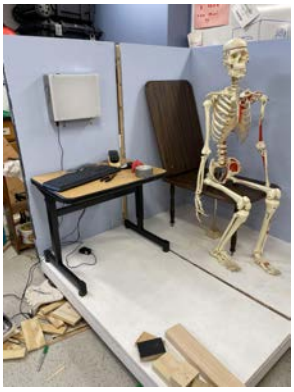
Materials:

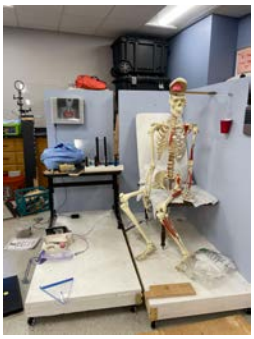
- Stethoscope
- Skeleton
- Magnets
- 3D prints
- Plinko board
- Desk
- Laptop
- Table bed
- Paper clips
- Marbles
- Weights
- String
- Pulleys
- Funnels
- ipad
- Wood
- PVC pipe
- Clear tubing
- Syringe

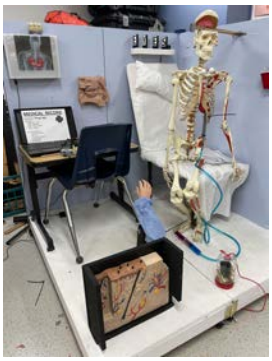
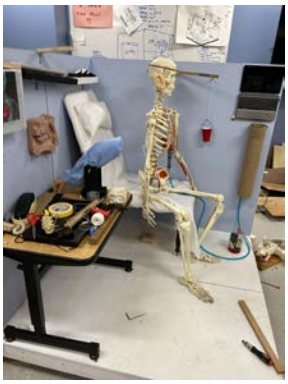
3. Progress Documentation

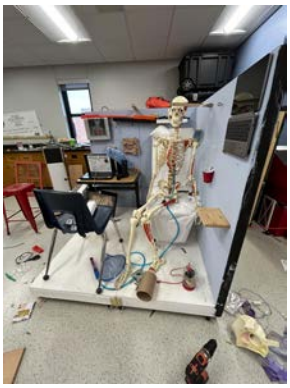
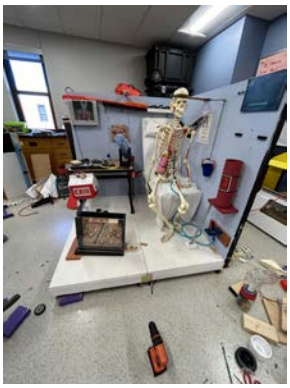


Date	Description of work	Progress Photo
11/16/23	All the holes are filled in the plywood box from previous year's project. We got the wheels on. Started sanding it down.	
11/20/23	Sand down more	
11/20/2023	Paint the walls with primer	
11/24/23	Sand and fill more holes	
11/27/23	Repaint walls light blue	
11/30/2023	Sketches out design on whiteboard	
12/4/23	Add second coat of light blue paint	
12/5/23	Paint the floors white	
12/7/23	Design ideas	
12/12/23	Sketch things out on paper	
12/20/23	Get the skeleton from the anatomy teacher	
1/9/24	Fix the skeleton	
1/15/24	Cut the skeleton's pole so he can sit	
1/18/24	Painted skin and nose models	

1/22/24	Brainstorm on the whiteboard more	
1/25/24	Got the skeleton in place, figured out where we wanted him at the time being.	
1/29/24	Changed our idea, thought the skeleton would look better sitting on the “doctors table”. Got the skeleton in place, moved the table under the “X-ray” (light box).	
2/1/24	Did some more brainstorming. Added the computer, rotated the skeleton to where we wanted it.	
2/6/24	3D printed the heart, brain, and eyes	

2/8/24	Got the bed for the skeleton to sit on, the brain of the skeleton is assembled. Figured out what we wanted on the table, got the iPad mounted on the wall with velcro strips.	
2/12/24	Started working on the hydraulic step. Figured out how we were going to incorporate it into the machine.	
2/15/24	Added the broken heart transparency picture onto the light box. Figured out the bed completely. Brain step finalized and working.	
2/20/24	Added the nose onto the wall, figured out how the computer was going to be in the machine. Got the starting component figured out.	
2/22/24	We figured out how we are going to incorporate eyes into the machine to get his eyesight back.	

2/26/24	We got the EYES dominos on the wall all figured out. We used an arm and figured out an idea for a plinko board with the skin cell model, we also worked more on the hydraulic step	
2/28/24	We thought of ideas on how to turn on the light box with the wood plank. The nose was officially attached to the wall. We got the ear so he could get his “hearing” back	
3/1/24	We connected the starting point to the dominos. We worked more on the hydraulic and electric steps	
3/5/24	We changed the starting part to a hot wheels track. We figured out the eye part so it completely works, we also figured out the arm part of the machine.	

3/8/24	We finalized some things and had to take some things down to rethink things.	
3/9/24	We connected all the steps together, had to think of some more steps and connectors. Used weights and strings to our advantage.	
3/11/24	We finalized some steps and connected all the pieces together, making things prettier. Added decorations like biohazard containers, transplant sign on cooler, etc.	
3/13/24	We finalized everything and wrote the step list. Each step has an object with the energy and a simple machine or advanced component that makes it work. Labeled all steps and advanced components on the machine.	

4. Major Successes and Challenges

Challenge #1

Problem

There was a switch on the top of the x-ray lamp that we wanted to turn on with a Hotwheels car. However, we tried many things and we couldn't get it to reliably turn it on while performing its other tasks.

Proposed Solution

At first, we proposed having a popsicle stick on the switch to extend it, and have a slot in a rail that the car would run over. This did not work, as the popsicle stick was too much of a bump to run over. Then Kael realized that if we used a hot wheels launcher, the bottom side of the launcher would hit the on button, while propelling the car forward.

Success

After several adjustments, we got the launcher to consistently hit the button every time.

Challenge #2

Problem

On the hydraulic step, there is a large syringe that needs to be pushed down for the heart to be pushed up. The syringe needed a lot of force or weight and releasing all that weight was very difficult.

Proposed Solution

At first we wanted to drop a weight down a tube with a pulley, but it was too much weight to hold up. Then we tried a first trapdoor configuration, but the release mechanism wouldn't move because of all the weight.

Success

After some more thinking and working together, we thought of a way to make the bottle of weights drop down a tube to make it land on the syringe, pushing it down.

Challenge #3

Problem

One of the biggest problems we came across was figuring out how to get the brain to drop down into the skull.

Proposed Solution

At first, we started with a pulley using a string, and a red plastic cup. That didn't work very well because the string and plastic cups would break all the time. We did not know how to fix the problem.

Success

We found a stronger rope and stronger pulley system. We found a bigger and deeper cup that would be able to catch the weight without it breaking. It did work and that component of the machine is still there and working.

5. Final Machine

Description

The machine our team built resembles a doctor's office by putting parts back on the patient, Doug Upp. In the beginning as the vertebra gets adjusted, it turns on the X-ray machine that shows the patient's broken heart. The patient's hearing is restored when the vertebra passes. After the hearing gets restored the vertebrae starts the patient's EYES exam. With the drop of the weight the eyes get pulled back into the patient's eye sockets restoring the eyesight. Then the brain gets dropped back into place in the skull and it closes. So now the patient has a mind of its own. Later on the patient can smell again with the help of thedoctor's hand picking a booger out of his nose. Then the doctor's hand also helps the patient breathe again by inflating the lungs. With the help of the lungs (balloon inflating) pulls a wedge releasing a white blood cell. The white blood cell then goes through the skin in search of infection to release the biohazard container which makes the patient's blood pump and pushes the heart up into his chest. The heart then releases a pin restoring the patient's heartbeat and bringing him back to life. We reverse engineered him using technology - 3D printing, organ transplantation, infusion, chemical reactions, computers, X-rays, and iPads!

This medical symbol shows the numbered steps. The machine starts with the switch on top of the X-ray box on the left hand side of the machine. It ends by turning on the heart rhythm on the iPad at the top right of the machine.

This symbol shows where the advanced components are located in the machine.

- There is one electrical cord going to the machine to power the X-ray box.
- The iPad is charged with batteries.

Major Redesigns from Original Idea

- One of our biggest redesigns was how to make the Plinko board work. Our team went through many ideas and designs before we figured out what we wanted to do for the Plinko board. At first we had no idea what to do with it but we wanted to do something with the skin model. At first we were going to have something roll off the top of it. We couldn't quite figure out how to make that work. One member on our team thought of the idea to make it a Plinko board. Our first revision of the board didn't work. It didn't Plinko like we wanted it to. Then we took it back to the beginning stages, we took everything apart and restarted. It took many tries and now we finally got it to the stage we have it at now.

6. Machine StepList -

The **red** word in each step indicates which **object has the energy.**
The underlined word is the simple machine used to create a mechanical energy transfer.
Blue is the fluid power step.
Green is the electric step.
Orange is the chemical reaction.

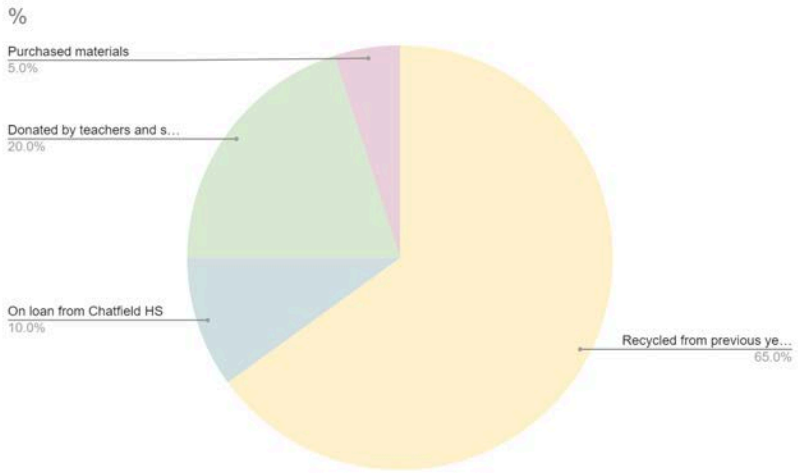
1. The patient's exam starts with a section of **spinal vertebrae** getting adjusted using a spring.
2. As it travels down the ramp, the spine also turns on the X-ray box revealing the broken heart. The spine releases the neck tension to reattach the ear and restore the patient's hearing using magnets. At the end of the ramp, the spine activates the **E-Y-E-S exam dominoes** that fall over on first class lever hinges.
3. The final domino knocks a **weight** off the shelf that pulls the eyes back into their sockets to restore the patient's eye sight using gravitational potential energy.
4. The weight pushes down on the input arm of a **first class lever** that spins on its fulcrum lifting the output arm.
5. The output arm of the lever lifts the end of the **pointer finger** on a second lever directing the patient to read the eye chart on the wall.
6. The pointer finger slides forward on a track that has become an inclined plane and knocks a **weight** into the sample collection pail.
7. The heavy **sample collection pail** moves down on a pulley.
8. The sample collection pail pulls a string attached to a wedge holding up the **brain during** the exam, making it fall into the skull.
9. When the brain falls into the skull, the **top of the cranium** can close, pulling a string attached to the human organ cooler by the desk.
10. Gravity makes the **human organ cooler** fall off the desk,
11. pulling a rope attached to the doctor's **computer** to close it on a first class lever hinge between the keyboard and monitor.
12. The computer pulls the doctor's **stethoscope,** releasing a weight off of the nose.
13. When the weight falls, the **doctor's arm** falls forward on a first class lever and pulls the booger out of the patient's nose, clearing his airway.
14. Once the airway is clear, the **balloon** dumps baking soda into the pink lung, creating a chemical reaction with vinegar that produces carbon dioxide and inflates the patient's lung.
15. The inflated lung releases a wedge from the **white blood cell** in the skin. It falls through the skin plinko board looking for infection and
16. lands in the collection tray onto a **mousetrap** spring.
17. The spring pulls a string attached to the wedge holding up the **biohazard container**.
18. The heavy biohazard container falls onto the **IV syringe** going into the patient's vein with blue blood and depresses the syringe. The other end of the blood fluid power system lifts the heart into the patient's chest where it belongs.
19. The restored **heart** releases pulls a tripwire that
20. pulls a pin to release the flatline and restores the patient's **heart rhythm on the electronic monitor**.

7. Cost of Machine and Percent of Recycled Materials Used

Material	Source	Cost
Plywood display box on casters	Grant from previous year projects	Recycled = free
Paint	From Olmsted county recycling facility	Recycled = free
Mousetraps	Hardware store	$6.00
Hydraulic hose, command strips, Goo Gone cleaner	NAPA	$15.12
Skeleton	Anatomy class	Recycled = free
Exam tables	Donated by teacher	Recycled = free
4 L-brackets	Ace hardware	$4.49
Hardware - screws, brackets, hinges	Recycled from previous year's projects	Recycled = free
Wood scraps	Gathje Cabinet Shop, PI	Recycled = free
Desk	Chatfield HS	Recycled = free
Laptop	Chatfield HS - technology waste	Recycled = free
Ear, brain, heart, eyes, white blood cells	3-D printed by Kael Simpson at home	Donated 3D resin materials
Large Syringes	Donated from teacher at school along with feeding tube supplies no longer needed	Recycled = free
Fishing line, rope, string	Recycled from previous year's projects	Recycled = free
Peanut butter jars, tupperware	Family recycle bin	Recycled = free
Weights	Physical Science classroom	On loan
White sheet	Donated by teacher	Recycled = free
Spine section	Door prize from convention	Recycled = free
Car and ramps	Old toys form students	Recycled = free
Cooler	Teacher donation	Donated
iPad	Chatfield HS science teacher	On loan
X-ray light box	Chatfield HS science department	On loan

Plexiglass	Recycled from COVID cough screens	Recycled = free
Skin and nose 3D models	Old anatomy models	Recycled = free
Large white marble	Science Teacher	On loan
Latex balloons, vinegar, baking soda	Science department - consumable budget	Minimal cost - absorbed by chemistry classes
Toy stethoscope	Student toys	Recycled = free
Pointer hand	Science teacher	On loan
Total		**$25.61**

Percent of Recycled materials



8. Team and Individual Reflections of Entire Process

Team reflection:

↪ This project helped build our problem solving skills and forced us to be more patient. When things didn't work out it could be very frustrating, but we soon understood that this project would take time and patience. We all learned how to effectively communicate and take leadership roles for the tasks we needed to take on. This project had many bumps in the road like things not working or breaking, but when you reach a point of success it is all worth it.

Individual reflections:

Maddie:

↪ I felt as though the project allowed me to think in different ways that I don't usually do. There was a lot of problem solving with many aspects of the project and I had to think how to fix it. When we were putting up the syringe with the weight, the syringe was not strong enough to withstand the amount of weight. I had to think of different ways we could hold it up at the right height that could withstand the amount of weight and not be bulky.

Ella:

↪ When I first got introduced to the project I was a little nervous and worried about how a team of highschoolers was going to be able to do this task. As the project started going and time went on I got faced with a lot of different challenges. I had to problem solve and think more about the future than I normally would. There were a lot of different aspects of the project that made me upset, frustrated, and confused.

Brady:

↪ This project challenged me in many ways, i wasn't exactly sure what we needed to do to get done. But when we communicated and worked as a group, things started to click and we were able to push through. It was difficult for me at times and caused a lot of confusion for me but my team helped support me. I was able to figure out the chemical reaction ratios and the way the balloon sits on the water bottles.

Gavin:

↪ When I first started I did not have many ideas on different topics and problems. This project really changed the way I thought about solving problems in many ways. It had mechanical issues that we had to resolve which really made me realize how to transfer energy from one thing to another. At times it would get really frustrating when a problem had no obvious solution and it seemed like we had tried everything. Then we would think of something really creative and the sense of accomplishment was very rewarding.

Kael:

↪The project allowed me to think in many new ways that I don't normally think of. There were many problems within many parts of the project and I thought about how to fix it. I thought of different ways to mount or hold different objects for the best success rate that could withstand what we put it through and it's not too bulky.

Andrew:

↪ When I started on this project it made me feel nervous and overwhelmed like we were not going to complete it. I was also confused but with the help of our team and Ms. Gathje we got it done. By doing this project it helped me with problem solving and pushing through difficult situations. It also improved my ability to work with others and brainstorm ideas past my normal limits.

9. Connection to future application

This project helped us to better understand how to communicate and work together as a team. In the future we will have to be able to communicate with other peers and share ideas/strategies with your team or managers. Trial and error is frustrating but if you stick with it long enough and work together, it usually gets fixed. This experience will help us in our future careers.