Pius XI Catholic High School:

SpaceXI

Engineering Machine Design Contest

Team Members: Casey Brophey, Kim Albright, Elise Sepulveda, Drew Miller, Ellie Baudry, Murphy Roszak, Zach Nowak, Katie Mendez, Sam Christian, Raul De Jesus, Michael Reed, Anthony Ehlinger

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Monthly Overview:

September: We had our first meeting on September 21st. We kicked off this year by learning about the theme of this year's competition, *Into Orbit: Transforming Space Technology,* then we immediately started brainstorming ideas for our board this year.

October: Lots of planning and prep in October! We each individually read the Rule Book for the competition to identify constraints in building. We also split the board into quadrants and the team into small groups for each quadrant. Then we did more individual brainstorming and lots of group brainstorming for an overall theme, goal, and interpretation for our board. In late October, we took a trip, as a team, to the **Science and Industry Museum in Chicago**, to get inspiration for our engineering process and generate new ideas. Finally, we did all of the safety tests and tool training.

November: At the beginning of November, we started to work on **sketches individually**, then came together as a group and created sketches. Then we finalized sketches for each group and got **right into building**.

December: We continued to build our individual groups' steps and most groups were very close to finishing by the end of the month. We still needed to finalize, test steps and assemble steps on board to complete the board.

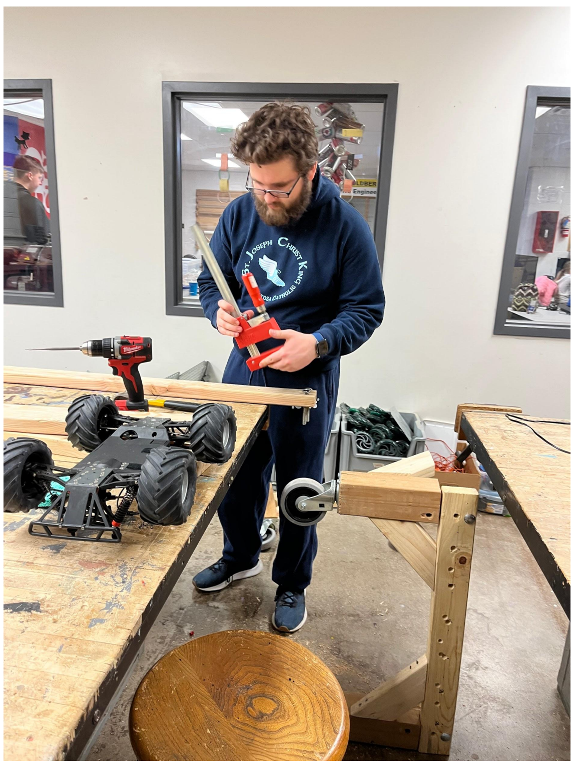
January: In January each group finished building and testing their steps. Each group **tested the efficiency** of their steps at the end of the month. We were also able to build our baseboards, once they were primed. We were also able to complete painting our background design on the baseboards and started to add our steps onto the board.

February: In the month of February we completely finished adding our steps onto the baseboard, then started brainstorming connection steps between each group's steps. We were also able to make a lot of progress on our journal and presentation script.

March: We began the month by having our First Run Night. We all had our families come and watch us fully run our machine with all the steps together for the first time. We continued working on the journal and the team presentation, while continuously testing the board all together to make sure it is fully working by our regional competition.

April: After regionals we took a break, then continued to test the board while revising our team journal. We also improved our oral presentation in learning it further, so we are more comfortable in speaking our parts.

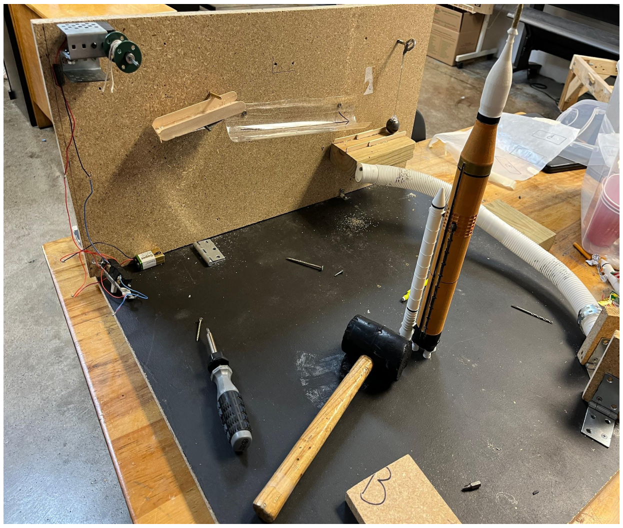
<u>Progress Photos:</u>



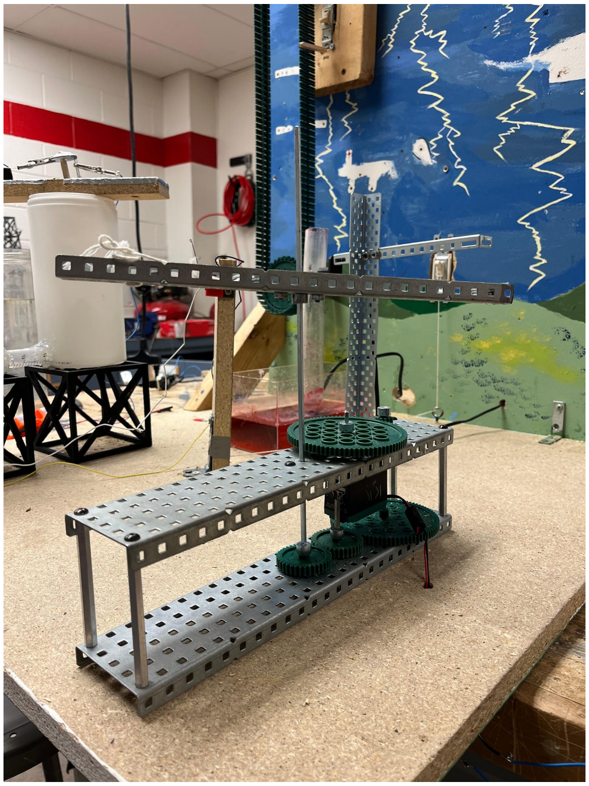
Deconstructing the previous year’s board

Team Trip to Museum of Science and Industry in Chicago

Individual Practice Board
Construction

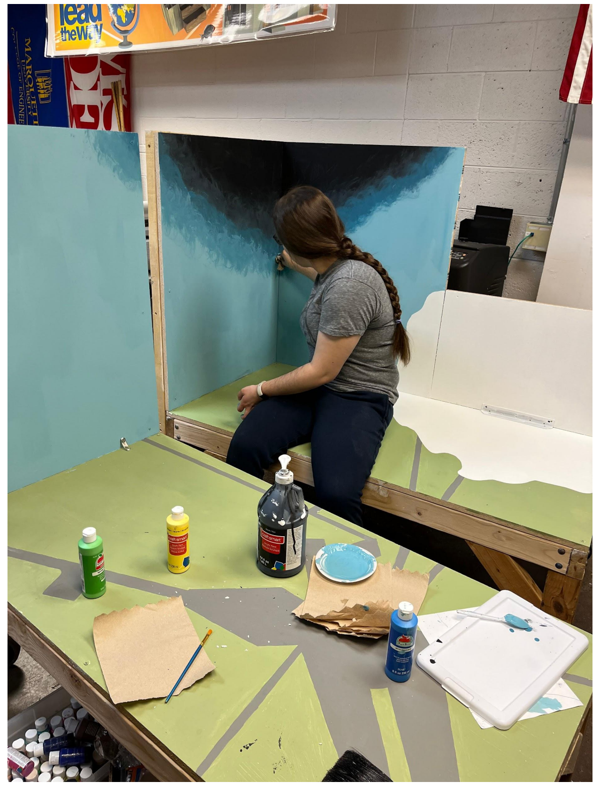


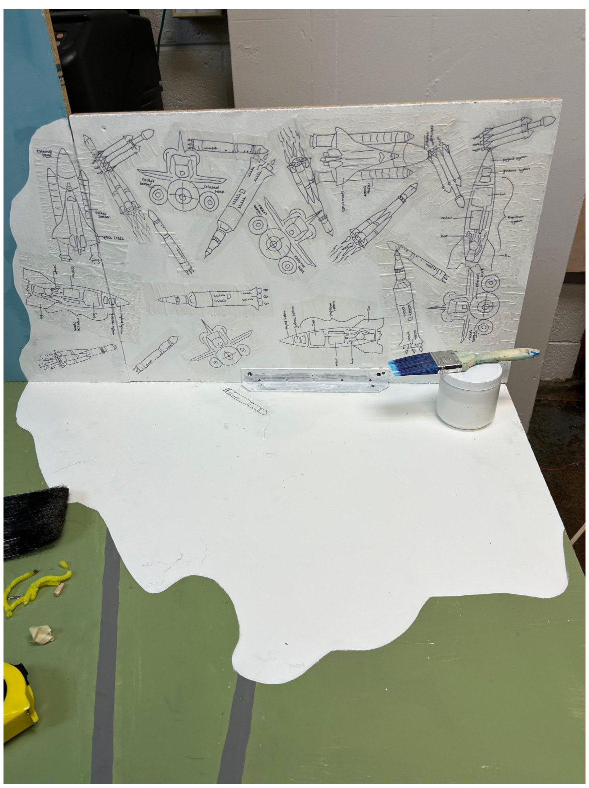

TAC 110
BIRTHDAYS
WISCONSIN
MSOE




XI


SUNS
VOLLEYBALL

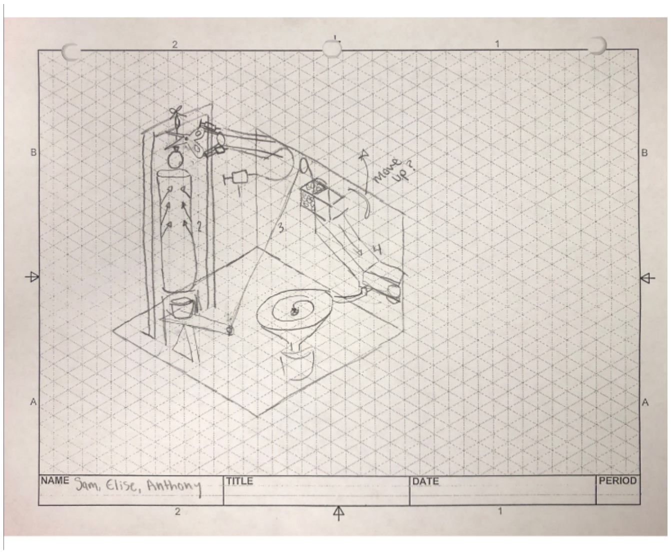
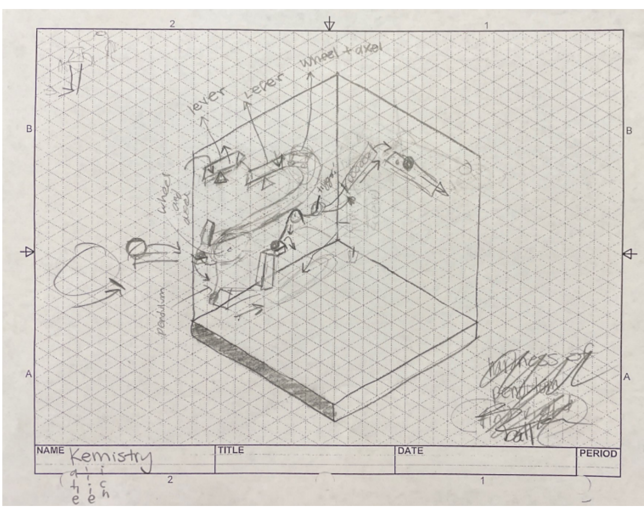


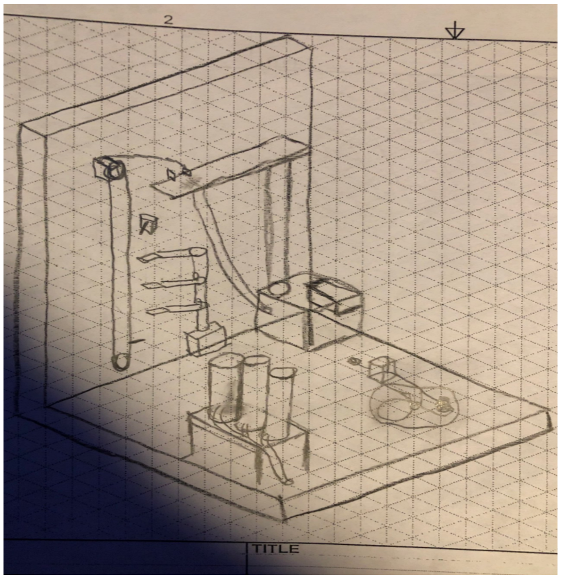
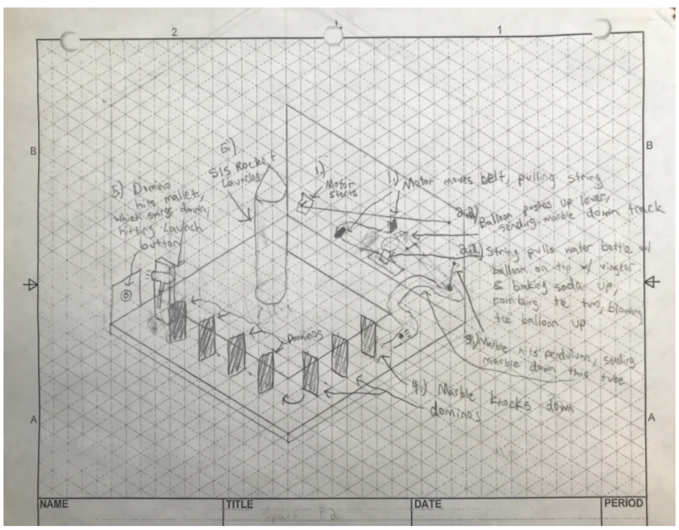


Final Board Painting and
Preparation

Final Board Construction
Process

Initial Sketches and Designs:

1		To start, a team member presses in the ‘push’ button attached to a syringe filled with water. The water travels through a tube into another syringe, causing the plunger to expand. The expanding plunger pushes against a hydraulic arm, causing a pair of scissors to close on the fishing line which is holding up a water balloon. The water balloon is released into a tube lined with nails. The nails pop the balloon and the water is gathered in a container through a funnel. The weight from the water collecting in the container offsets the lever, which tuggs a string, pulling up a door to release a swarm of marbles. The marbles run down a ramp and collect into a container which offsets another lever. The lever pushes a marble to roll down a funnel, which would simulate a black hole.
2		Our steps start when something activates lever #1 and pushes it down causing the reaction upon the second lever. The movement of the 2nd lever causes Thomas the train to be activated. Up until the activation point the train is held idle using magnets. Using the South and North Pole of the magnets to keep it still, once the lever with a magnet is moved Thomas gets released. From there Thomas goes down the tracks onto an oscillating circle wheel. He activates the ball that later continues to activate the wheel. The wheel which has a ball pendulum attached is activated and triggers the wedge. The wedge comes in contact with a supported platform with a ball on top. When this is activated the balls fall off triggering the pulley to pull out the nail in the screws causing the screw to rotate the marble up and out leading out to the inclined plane.

3		Our original steps start out with a water pump pumping water up a tube to a platform with two electrical contacts. When the water touches the contacts, it connects a circuit powering a motor connected to a belt with a peg on it. That belt and peg would spin, eventually flipping a switch powering a centrifuge. That centrifuge would then release a weight on a string spinning so that it would flip a switch starting a motor that would pull a plug in a water tank draining the water.
4		Our initial design starts with a motor that moves a belt, pulling a string. The string pulls a water bottle with a balloon on top, releasing baking soda into vinegar in the bottle which blows the balloon. The balloon blows up and pushes up a lever which sends a marble down a track. The marble hits a pendulum, redirecting the marble into a tube. The marble hits a domino which knocks down a line of dominos. The final domino hits the handle of a mallet which causes it to swing into a button which starts the launch sequence for the rocket.

How we used the Design Process:

1.) Define the Problem:
   - ➔ We started off the year individually reading through the rules and regulations for the Engineering Machine Design Contest. Also learning the theme for our machine.

2.) Generate Concepts:
   - ➔ Our team had multiple meetings sitting together and brainstorming ideas. Talking about specific steps we want to incorporate into our machine, how we can create them, insure they are plausible and dependable, while connecting them to the overall theme. We also made clear how each group is interpreting the theme, which is why we show the process of launching a rocket all the way from the beginning of the Design Process. After this we each individually created initial sketches of steps we each wanted to include in our sections of the board.

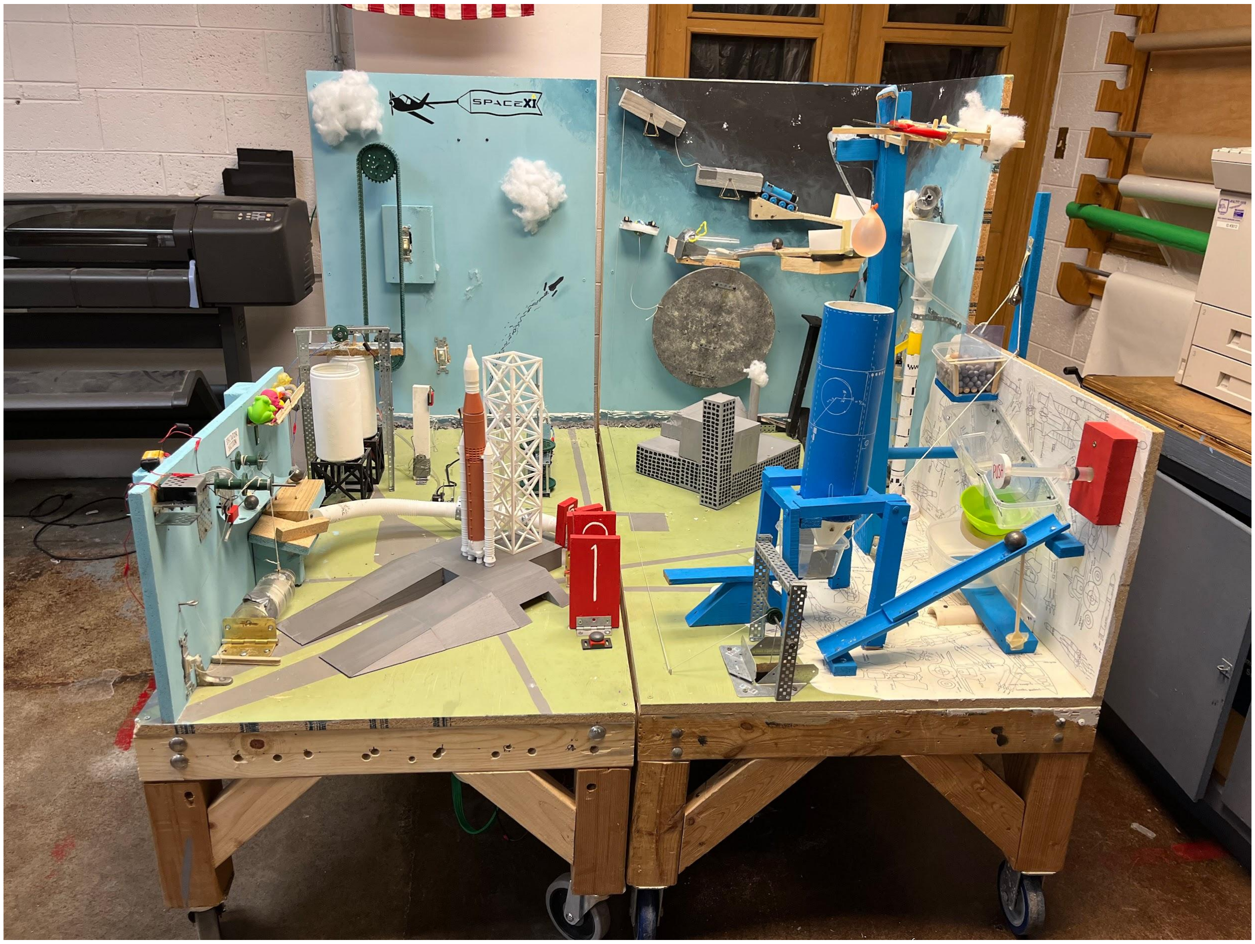
3.) Develop a Solution:
   - ➔ After creating our individual initial sketches we got together in our small groups, for each quadrant, and created a group sketch combining our ideas. Each group sketch included four to five steps, therefore the total board has sixteen to twenty steps, to meet the requirement.

4.) Construct and Test Prototype:
   - ➔ After the group sketches were completed and approved we got started on building the steps. Each group was given a practice to board to build their steps on. It took around three months to completely build the group's steps just on the practice boards. Then we ran the steps countless times and began testing the steps efficiency and steps completion.

5.) Evaluate Solutions:
   - ➔ After each group's practice board was completed and working efficiently we were able to finish constructing our main board to transfer all the steps onto the main group board. Once all the steps were attached to the board we were able to brainstorm, construct, prototype, and evaluate connection steps between the groups steps. After all steps were completed, we tested the board countless times until it worked properly throughout the board.

6.) Present Solution:
   - ➔ Once the board worked to its full potential we were able to present our machine to our family and friends, now and later, here at regionals.

Final Project:



Description:

In our board we interpreted the theme of *Into Orbit: Transforming Space Technology* by creating a machine with an end goal of launching a rocket. We have the machine split into four quadrants, each representing a stage of launching a rocket. The first is representative of the brainstorming stage and Generating concepts, the second represents Development of solutions as well as conjoining materials. The third section shows the prep of the launching of the rocket, for example fueling the rocket with two white tanks. The fourth and final section has the rocket and eventually launches it at the end, with a countdown and watching area.

Machine Steps: *(20 steps max)*

1.) We start with our fluid power step. By pushing on the “push” button we are using air pressure and water to extend the other side of a syringe. This pushes on scaffolding to close a pair of scissors.
2.) The scissors close on a fishing line holding up a water balloon. Attached to the end of the fishing line is a water balloon which then falls and is popped in a tube lined with nails.
3.) The water from the balloon pushes down a lever which releases a container of small balls and marbles.
4.) These small balls and marbles fall into a funnel to activate an additional lever which then pushes a ball down an incline plane and into a can. The can pulls a string attached to a lever, which pulls down the lever and triggers another lever. Upon movement of the second lever the two magnets detached causing Thomas the train to go down the track.
5.) The train then hits a marble causing it to roll onto a moon platform which pulls out the marble #2 allowing the wheel and axle to pivot downward.
6.) The platform of the moon hits the wedge causing it to push the lever down. The force of the lever bumps a switch down activating the motor to the electric screw.
7.) Screw causes a marble to move upwards and when it reaches the end of the screw it falls out into a funnel.
8.) The funnel guides marble #4 down a ramp and hitting marble #4 goes into a tube and onto lever #2 which activates a flipping of a switch.
9.) The switch activates a water pump, the water is then pumped up through a tube toward a color detecting sensor. The water is dyed red so when the water passes through the sensor a cortex on the back can begin the next step of the board
10.) The cortex triggers a motor to turn on. The motor turns a continuous loop of treads that has a stick glued onto it. After a few rotations the stick is able to flip a switch moving onto the next step.
11.) The switch activates another motor located under the centrifuge. The high gear ratio means that the arm takes some time to spin up but it does have an overall high speed. The centripetal force pulls the washers along the arm until they are flung out. A string keeps them attached as it continues to speed up. The washers hit a wooden rod knocking it down.
12.) A switch on the end of the wooden rod activates a motor above the water towers. The motor pulls up a plunger releasing the water from the tank. As the water drains, a float starts to go down. Once the float goes all the way down a washer and a rod make contact on the top, which completes a circuit.
13.) The circuit turns on a motor that acts as a winch by pulling a string that is connected to a plastic water bottle which pulls the bottle into an upright position. Once the bottle is pulled into an upright position, a second string is pulled which flips a kill switch that shuts off the motor.

14.) The water bottle has four teaspoons of vinegar and a pipe separating one teaspoon of baking soda. When the water bottle is raised the baking soda and vinegar combine causing a chemical reaction creating sodium acetate, water, and carbon dioxide. The carbon dioxide blows up a balloon, hitting a limit switch.

15.) The limit switch starts a motor which pulls up a wooden pin, releasing a large marble down a ramp which eventually hits a pendulum and redirects the large marble down onto another platform and through a plastic tube.

16.) The marble hits a domino which knocks down another 4 dominos, each being larger than the previous domino. The last domino falls and hits a button.

17.) Underneath the board, there is a pressurized air canister that was pressurized prior to the run with a bike pump. The can is connected to a solenoid which is connected to a pneumatic cylinder/piston with a 3D printed SLS model. When the button is pressed, it opens the solenoid which sends the air into the piston, raising it and “launching the rocket.”

Advanced Components:

Type:	Description:
1.) **Fluid Power**: Sam, Elise, Anthony	When a button attached to a water filled syringe is pressed, it extends a plunger in a separated syringe in order to activate an apparatus that compresses scissors to cut a piece of fishing line.
2.) **Mechanical:** Katie, Ellie, Michael	Our advanced component consists of the six simple machines. We are actively using the wedge in our transfer of energy step from our wheel and axle to our lever arm. Our screw is being activated by a vex motor. A ball is transported up the threads moving the ball. Pulleys are also used elsewhere on the machine.
3.) **Electrical:** Zach, Raul, Murphy	Once the peg flips the switch, a circuit is connected causing the centrifuge to spin. The centrifuge uses a motor to spin a long arm. The gear ratio in between allows us to achieve speeds that are higher than the motor itself could achieve. This however, can give off some torque but it gives us a cool slow spin up.
4.) **Chemical:** Casey, Drew, Kim $C_2H_4O_2 + NaHCO_3 \rightarrow NaC_2H_3O_2 + H_2O + CO_2$	A motor activates to spool a string which in turn rotates and raises up a bottle separately containing baking soda and vinegar. A change in the bottle causes them to combine which causes a chemical reaction, and produces products of carbon dioxide gas, water, and sodium acetate. The carbon dioxide gas rises causing an expansion of the balloon which is connected to the top of the bottle, thereby initiating the next step.

<u>Materials:</u>

	Quadrant #1:	Quadrant #2:	Quadrant #3:	Quadrant #4:	Base Materials:
Recycled Materials:	Scissors Rubber band PVC pipes Funnel String Pulley Marble 2 syringes Plastic tubing Hinges Wood fulcrum PVC fulcrum Wood pieces Scaffolding Water balloons Water Nails Screws Masking tape Metal bracket Plastic BB's Cup	Wood blocks Balsa wood Plastic flask Graduated cylinder 1 9 volt battery Thomas the train and friends Train track Marble track Paper Vex motor Vex switch Vex axle Vex shaft collars Wheel Plastic tubing Foam Foam ball	Clorox containers Water pump Vex motors Light switches Syringe Vex sensor Cortex Gears String Wire Power outlet 9 volt Battery Spool Water Styrofoam Washers Wood Plastic tube 3D printed box	Vex motor 9 volt battery bracket/braces Spool and axle String Duct tape Shaft collars Popsicle sticks Screw Plastic tube Wood pieces Eye hook Ball Bearing Hot glue Epoxy Tubing VEX metal support Button Bungee cord PVC pipe Piston/cylinder	8 wheels 4x4 legs Assorted wood support structures Assorted bolts and screws
Purchased Materials:	-Paint pen -5 lb test fishing line -Plastic Tupperware		-GFCI outlet -Cord with switch	-YouCan -Schroeder to ¼ npt valve -¼ npt male to ¼ npt male -Solenoid Valve -¼ npt male to ⅛ npt male -⅛ male npt to ⅛ female npt 90 degree - Filament	-3 sheets of 6x8 ¾”particle board -4 7ft 2x4’s -6 ⅗”hex bolts

<u>Total Cost of Machine:</u> $236.25

Challenges:	**Successes:**
Our biggest challenge was coming up with the final step for our section. We miscalculated how many steps we had and needed an additional transition step. Our original idea for the step was a variation of a marble track. However, during construction we realized that this was not a transfer of energy and it needed to be changed. After multiple prototypes, we finally came up with a solution: a lever with a basket to collect our marbles with a stick on the other end to poke a ball down a ramp.	We had great success in building and assembling our initial steps. We took the time to think through everything that could go wrong ahead of time and were able to design quality steps fairly easily. Examples of this include our balloon dropping tube and our hydraulic scissor arm.
In the second section of the board, we struggled with getting Thomas the train to roll down the track and in order to hit a large marble onto the wheel and axle, making it spin. We redesigned the part to catch the marble and experimented with different types of guardrails to guide both Thomas and the marble down the tracks.	In the third section of the board, we thought building the centrifuge would be more difficult but ended up being quite easy by connecting a motor to a gear train and making an axle spin.

Individual Reflections:

Casey Brophey:	My group was tasked with the chemical reaction advanced component for the machine. My team had to do lots of research into potential chemicals and reactions we could utilize in our steps. This research has furthered my interest in chemistry and advanced my desire to be a chemical engineering major in college. It also taught me lessons about the need to test, revisit, and improve the processes we utilize. Many of the solutions we looked into were not functional but in the end led us toward our final destination.
Kim Albright:	I have been on our engineering team for two years now and have learned many things. This year especially I have learned a good work ethic, with pushing through, working hard by myself and with my team. I am planning on pursuing a career in the engineering field and being on this team has helped me narrow my decision of what specific engineering I would like to go into.
Elise Sepulveda:	Being on the team this year taught me resilience and determination. I started with many ideas in my head and at first could not put them onto paper. Eventually I learned what I needed to do to solve this setback and this will greatly help me in my future. I intend to go into architecture and have learned how to turn my thoughts into something tangible which will be more helpful that I can understand.

Drew Miller:	Being a part of this team has taught me the design process as well as the importance of teamwork. During the construction process of the machine, there were multiple instances when a problem arose and I had to use the design process to create a solution to that problem. The chemical reaction step, pendulum, dominos, and rocket system were all designed by my teammates and I using the design process. My teammates have shown me the value of being a team. On our team, everyone has had a role to follow that has all been very crucial. Finally, everyone on our team has learned that working together is important to succeed.
Ellie Baudry:	I have learned many things throughout this process. Working with a team is something I have always found valuable. This team especially was so effective. Being able to work alongside my peers and learn and develop new skills through a hands-on approach. The value of learning from other people in a team teaches so much. The special thing about this team was the eclectic variety of talents and skills we had. Throughout the processes we found each other's strengths and specialized in the roles we fit best. We worked through the engineering design process to continually improve and solve the problems we faced.
Murphy Roazak:	I learned that there are many ways to make something work. This has taught me to think outside the box and that there are multiple solutions. The first solution is not always the best solution. This can help me with future careers because I can use these critical thinking skills to solve real world problems.
Zach Nowak:	Since working on the majority of the electrical components on the board, I have been able to expand my knowledge of circuitry. This is primarily through using the vex cortex and wiring the solenoid. As well as learning how to work with the Air components that rely on the solenoid. This should hopefully give a kickstart on a future career in either electrical or computer engineering since both of these fields are primarily based on working with electricity.
Katie Méndez:	By being a member of this year's team, I have been able to gain a better understanding of my skills and how I fit into a team effort. I am mostly an independent person and, by pursuing a degree in computer science, it appears my future will be relatively independent as well. The group effort to design, construct, and problem solve the machine I have come to enjoy the multiple perspectives that come with teamwork. I hope that my new view on this will enable me to utilize my skills to collaborate with my peers in the future, in school and in the workplace.

Sam Christain:	Participating in the Engineering Machine Design Contest this year has been arduous at times, but extremely rewarding. I learned many times over why it is important to look a few steps ahead as things would always seem like they were working until I would look at the big picture. Seeing how everything works together and can be cohesive even with so many people involved has been very encouraging as I think of my future in industrial design. I have come to view teamwork in a new light and I hope to exercise this moving forward, both in my professional and personal life.
Raul De Jesus:	Being part of such a talented and creative group has taught me a lot of different things. I learned that every individual has a different way of looking at a problem and coming up with a solution. This can help me in a future career or project that I may find myself in. Going to a colleague for a different perspective can be extremely helpful in coming up with a solution. It also helped reinforce the principle that no idea is a bad idea because you can either learn from it or you can build on it. All in all I know the lessons learned with the team will help me overcome any roadblocks in my future.
Michael Reed:	I learned that in a group one can accomplish a lot more than on one's own. I can apply this by when in the futureI am given a big project I can ask others for help and get it done faster. We faced the challenge of a loop-de-loop not working as the ball that would run down it could jump off and make the machine not work so we replaced it with a straight line track. We had the success of meeting all the deadlines and getting the machine done on time. We had the challenge of the moon cracking so we wood glued it back together.
Anthony Ehlinger:	Throughout the creation of our Rube Goldberg machine I have learned many lessons through challenges and failures. One of the things that I learned is you need to prepare well before building and if you don't have exact plans it makes it very difficult to build how we want as we didn't have a last step which we had to improvise to create. Our second challenge was a container breaking. This was a problem as the runs were failing but we didn't know why until we went back to the most basic troubleshooting step of making sure every part was actually working. The third challenge we had was recalibrating our steps once we had replaced the broken part which we had to run our steps many times and through trial and error it was finally working again.

Word Count: 1410 words for the Personal Reflections and the Challenges & Success.

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