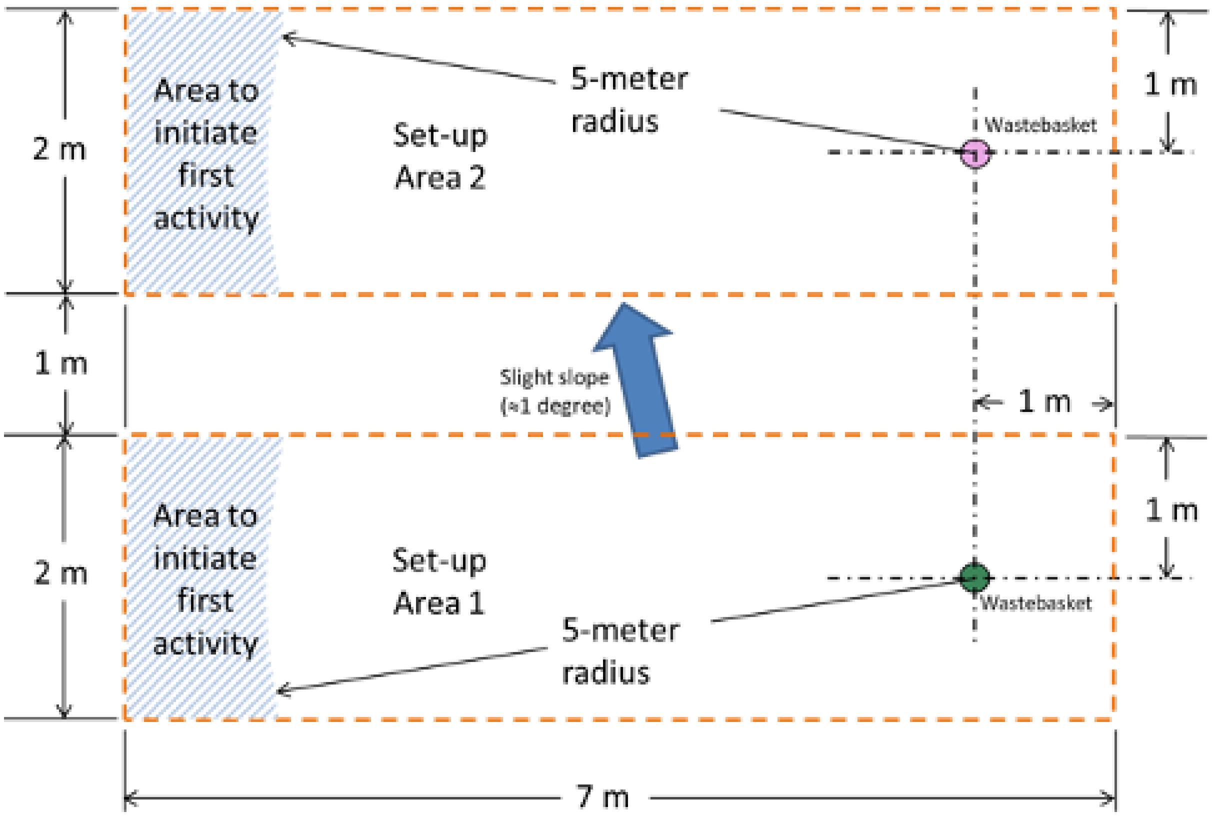
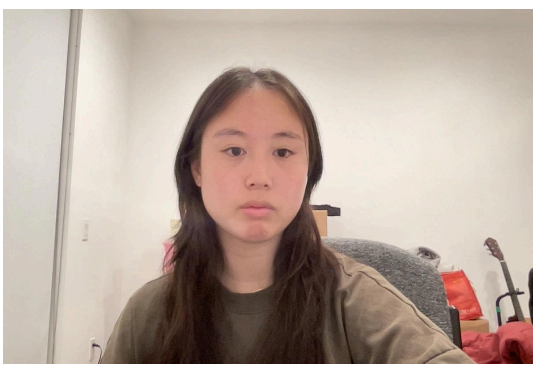
Low Expectations

Oliver Keeves, Shannon Lee, Lia Levin, Blase Londono, Daniella Rosenberger, Axel Wolfe



"Paper Basket Challenge"

About the Authors

Name & Picture	Bio
 Oliver Keeves oliver.keeves@gmail.com https://oliverkeeves.wixsite.com/oliver-keeves-capsto	Oliver Keeves is a senior at Santa Monica High school currently part of the capstone engineering program. He has taken PLTW engineering classes since freshman year, and has experience with basic aerospace, mechanical, and electrical engineering concepts. Outside of school, he enjoys sailing, surfing, and other watersports. He hopes to major in mechanical engineering.
 Shannon Lee shannonlee5129@gmail.com https://shannonlee5129.wixsite.com/engineeringportfolio	Shannon Lee is a senior at Santa Monica High School. She joined the PLTW program in her freshman year and has taken several engineering classes at Samohi since then. In the future, she hopes to major in computer science.
 Lia Levin liajlevin17@gmail.com	Lia Levin is a senior at Santa Monica High School and joined the PLTW program in her sophomore year. She has taken Aerospace Engineering, Digital Electronics Engineering, and is currently in the Engineering Academy. Outside of school, she enjoys figure skating and painting. She plans to major in aerospace engineering with a focus in astronautics.

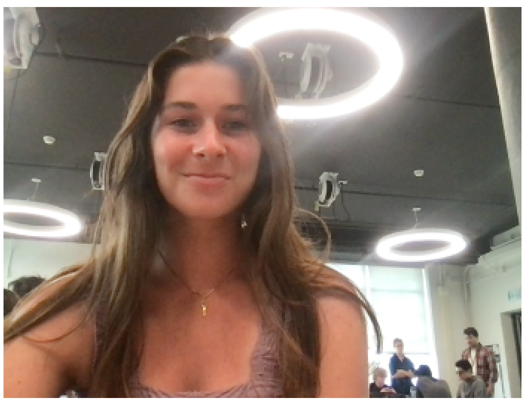
https://ljl232.wixsite.com/engineering-digital	
 Blase Londono blasejlondono@hotmail.com https://bjl247.wixsite.com/portfolio	Blase Londono is a senior attending Santa Monica High School. He has been a part of Project Lead the Way (PLTW) since his freshman year. Through PLTW's computer science pathway, he has become fluent in several object-oriented programming languages, including Python, Java and C++. Outside of the classroom, he is active on both school and club swim and water polo teams.
 Daniella Rosenberger daniellajader@icloud.com https://daniellajader24.wixsite.com/my-site	Daniella Rosenberger is a senior at Santa Monica High and has been in the PLTW program since freshman year. The courses she took included aerospace engineering and digital electronics, but she especially loves aerospace engineering. Apart from engineering she loves playing sports like tennis and beach volleyball.
 Axel Wolfe wolfeaxel@gmail.com Home | AxelWolfePltw2324https://wolfeaxel.wixsite.com/pltw2324/home	Axel Wolfe is a senior at Santa Monica High School. He started the PLTW program in his freshman year and has been in the program since. He enjoys the hands-on application of engineering through the program and has gained lots of beneficial knowledge from the program. Outside of school he likes to build and tinker, go on runs, workout, and play videogames. In the future, Axel plans to major in Mechanical Engineering.

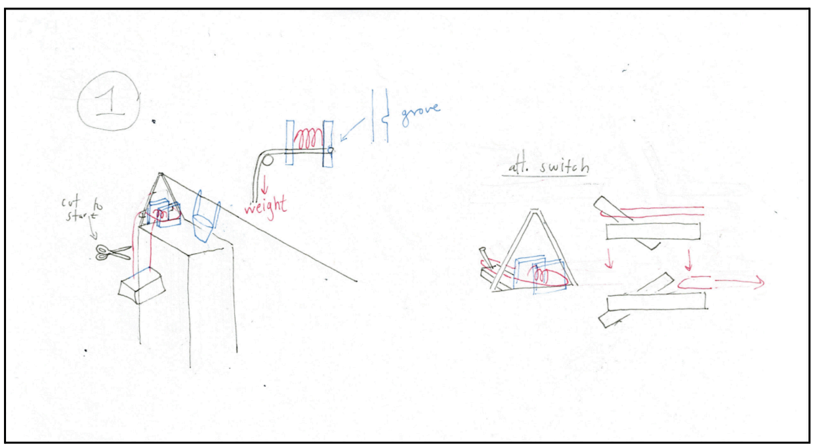
Table of Contents

Component 1: Rules/Research

Problem Statement:
Objective: Design and build a mechanism made of components capable of delivering a piece of paper into a wastebasket. The challenge is to successfully complete the task in the least amount of time.

Rules/Considerations:
- A total of seven or more distinct steps must be used from start to finish
  - The previous activity must initiate the next
  - Any activity can be repeated multiple times
  - No individual activity can travel more than 5 feet
  - The paper may start on the last activity
- Must use 3 different types of energy
- Machine must fit within the 2x7 meter area designated
- An object's speed cannot exceed 25 ft/s

Initial Research:

Team Member	Description	Sketch
Lia	The system will be initiated by a spring that is compressed, then released by a switch (or cutting a rubber band). The spring will expand to hit a bucket holding the crumpled paper and initiate its motion along the zipline.	 *Fig. 1*

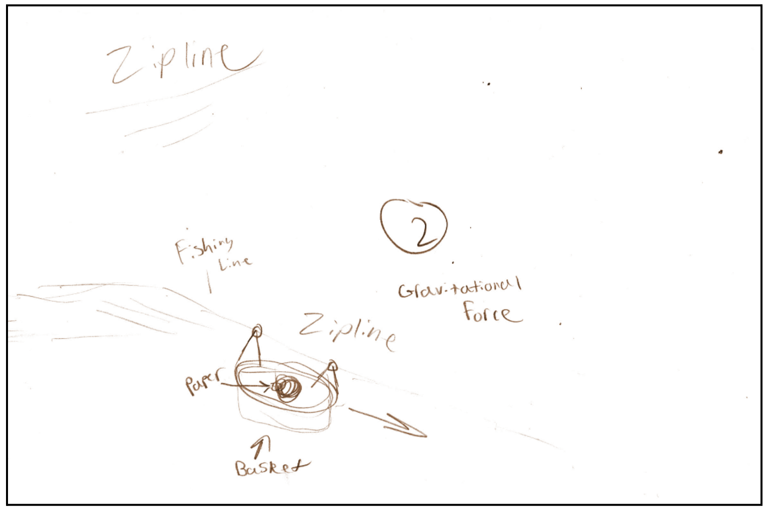
<table>
<tr><th>Team Member</th><th>Description</th><th>Sketch</th></tr>
<tr><td>Axel</td><td>Zipline will be initiated by the first activity using a weight that will be carried by gravity down the zipline. At the end of the zipline the weight will be used to activate the activity after that.</td><td>

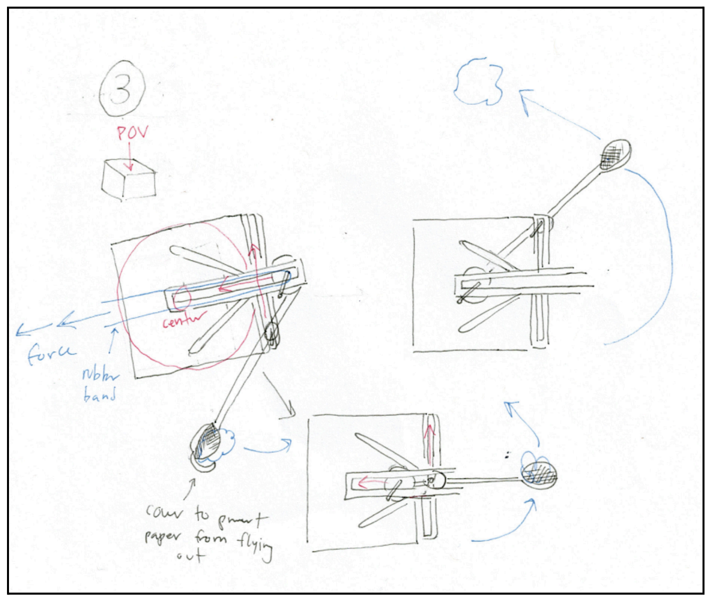
Fig. 2</td></tr>
<tr><td>Lia</td><td>The zipline will deliver and drop the paper into a holder connected to a catapult. The bucket hitting this component after the paper is in position will release a mechanism that pulls a dial to initiate rotation, which will then come to an abrupt stop in order to release the paper in a specific direction.</td><td>

Fig. 3</td></tr>
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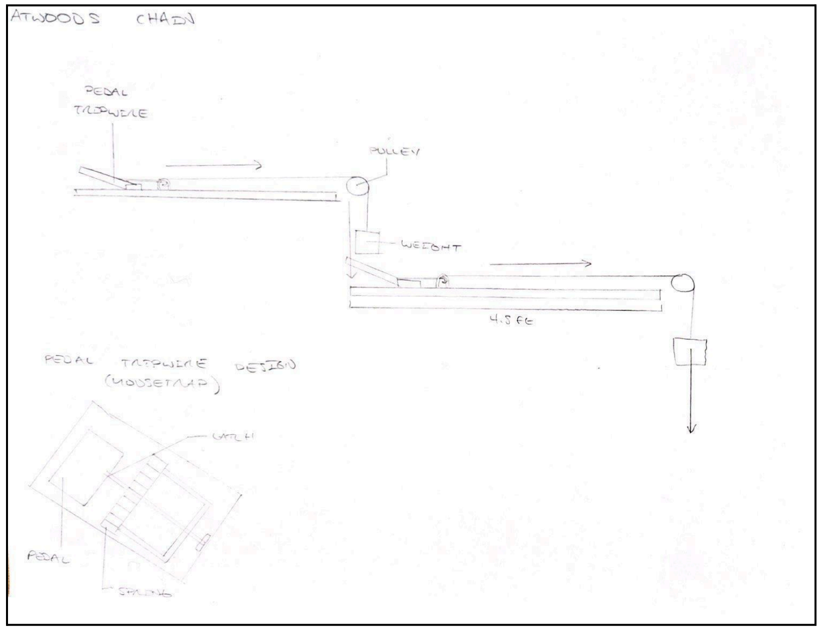
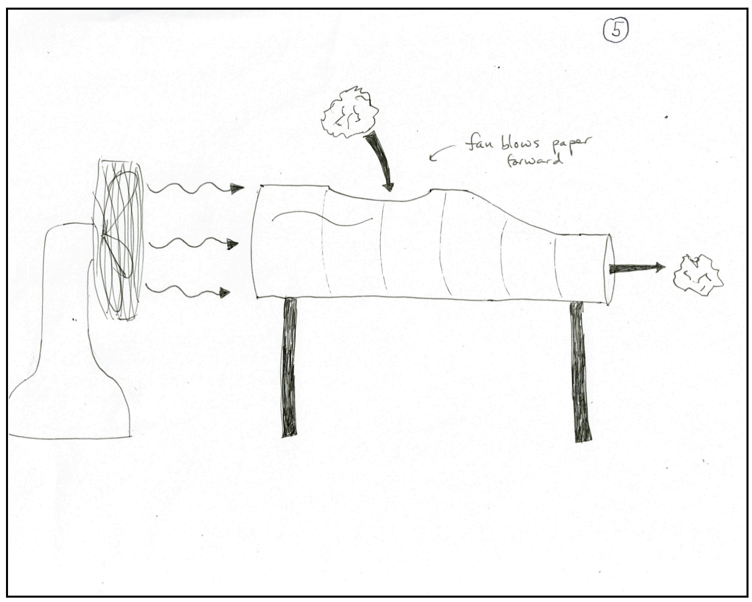
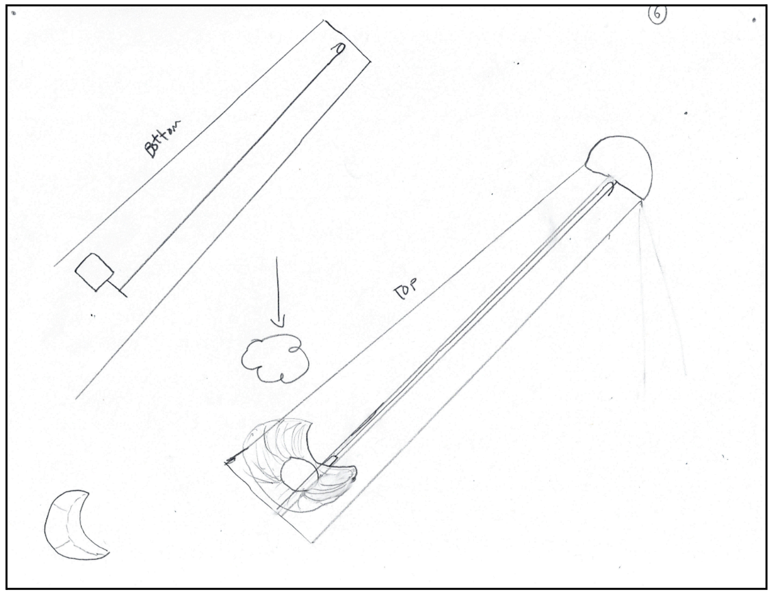
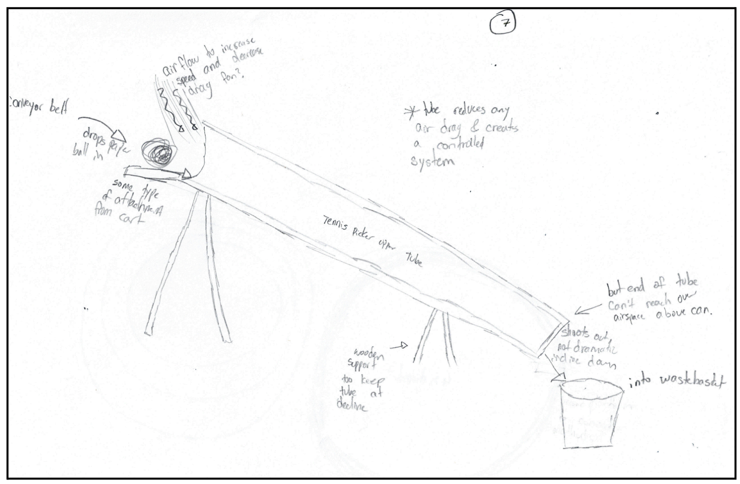
Team Member	Description	Sketch
Blase	A chain of Atwood's machines set to trigger one another via weight landing on a mousetrap pedal. We	 ***Fig. 4***
Shannon	A tube with a fan blowing wind through it is placed in front of the previous activity, with a hole for the paper to fall into the tube through. The wind will blow the paper through the tube and out the other end. This activity is powered by wind energy and electricity.	 ***Fig. 5***

Team Member	Description	Sketch
Oliver	A sliding track angled upward to elevate the paper upwards. A cart that holds the paper ball would be inserted in the track, and the cart would be powered with an electric motor that pulls in a piece of rope. The piece of rope pulls the cart up the track.	 ***Fig. 6***
Daniella	A simple angled tube will allow for gravitational energy with no wind interference. Held at an angle by two different built wooden support systems, it hangs to be right above the airspan, but not to land in the garbage can.	 ***Fig. 7***

Conclusion: Our initial thinking was to create activities that are as simple as possible. Simplicity would make physics calculations more straightforward and make the machine more reliable. We also wanted to eliminate unpredictable variables such as wind and friction, so we avoided designs that would freely launch the paper into the air. We ensured that the activity that moves the fastest would span the longest length possible according to competition rules, 5 feet, in order to decrease time to completion.

After re-examining the rules, our objective has changed, so some of our designs that were specifically created to accommodate a crumpled paper ball will have to be significantly altered. Our new goal is to create activities that are simply fast, as they do not need to carry the paper through the entire machine's span.

Component 2: Design

Initial Design Concept:

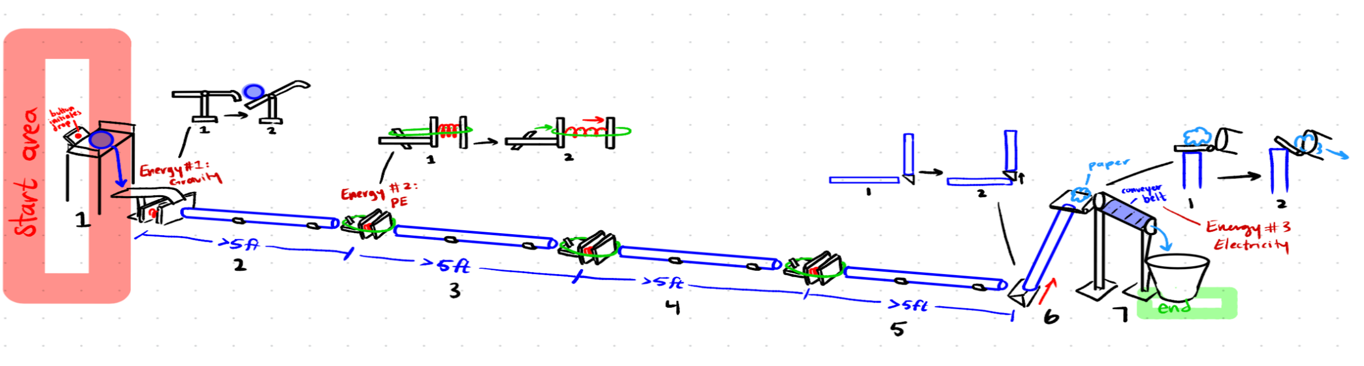


Fig. 8
Whole Prototype

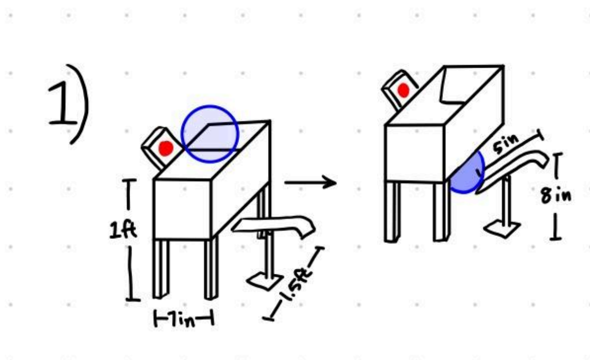


Fig. 9
Activity #1

For the start of our design, a ball bearing is dropped initiated by a button that is human pressed, since we are allowed a human initiated activity at the beginning. As the flaps open up from the button releasing them, the ball bearing uses gravitational power to begin the next series of activities.

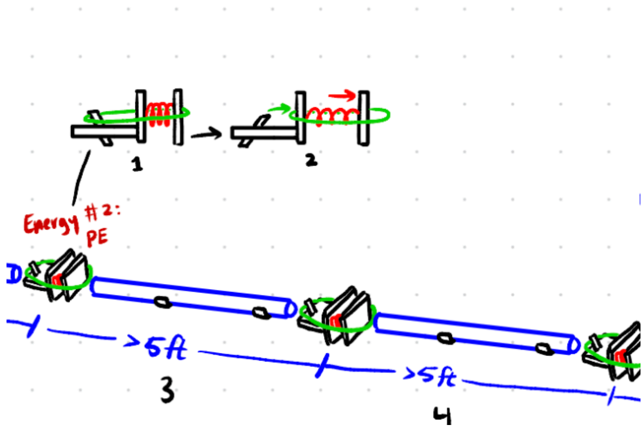


Fig. 10
Rod Activity

The next four of our activities are a repetition of one action, being launching a rod using a spring in order to trigger another spring to hit the next rod and so on. We are currently planning to use a pvc pipe for the rods.

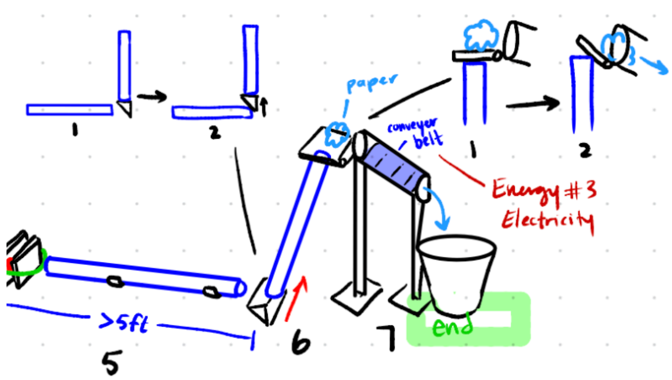


Fig. 11
Activity 6

After the repeating spring and rod mechanisms, the concluding activities will be triggered by the last rod in that sequence. It will hit a triangular prism shaped block, which will be precisely cut and angled to slide under a near-vertical rod in order to push it upward. This rod will then push a platform the paper is resting on, which will push it onto the next activity.

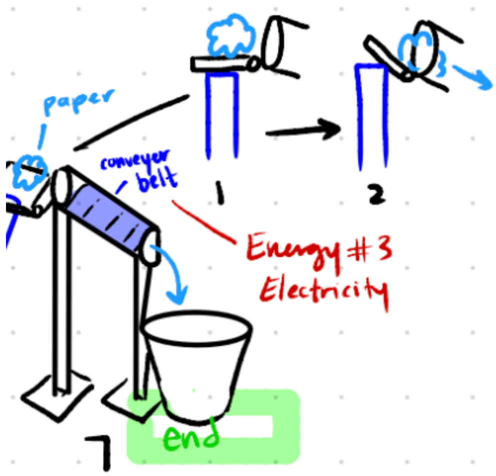


Fig. 12
Activity 7

The paper will be pushed onto a conveyor belt which will deliver it over the waste basket, and cause it to fall into it. We plan to make sure that the actual conveyor belt will not be over the airspace above the wastebasket.

Revised Design Concept:

Feedback:

- Make sure the last activity is reliable
- Confirm how each rod activates
- Make sure 3 forms of energy are used
- Add more reinforcements to keep the pipe straight/from moving
- Review expenses

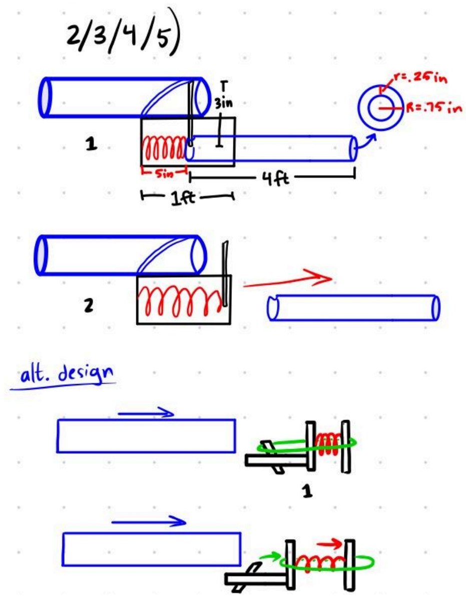


Fig. 13

The lever will release a spring that pushes a rod. This sequence is repeated with each rod activating the next spring for the next 4 activities. We now have two options for this design.

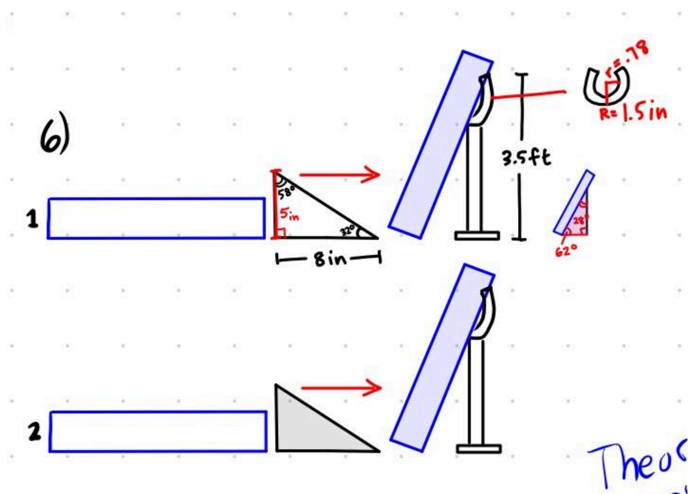


Fig. 13

The last rod in will hit a triangular block that wedges under a near vertical rod that is now being held up by a vertical stand.

Prototype Design Model:

- 3D computer model of your proposed design. The 3D model should include dimensioned part drawings and assembly drawings as necessary. Include all necessary dimensions, material callouts, notes, a parts list, and details necessary to construct a prototype of the product.

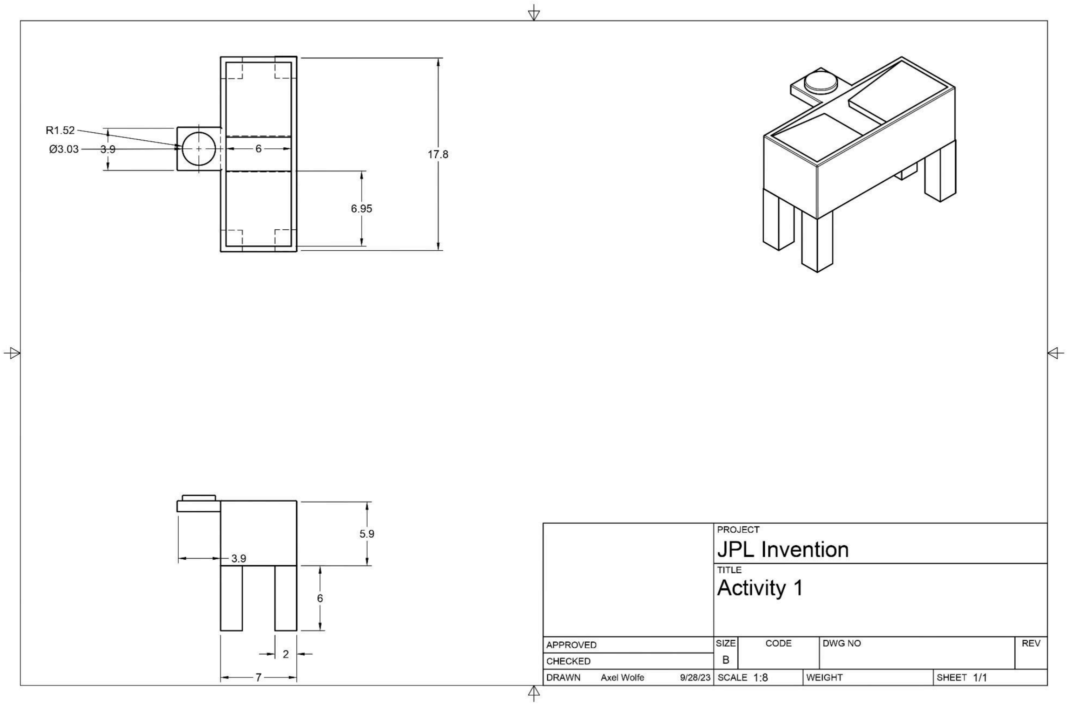


Fig. 14 Activity 1

This activity platform is made of wood planks nailed together. The button is wired to trigger wooden flaps to open and allow a small weighted ball to roll down.

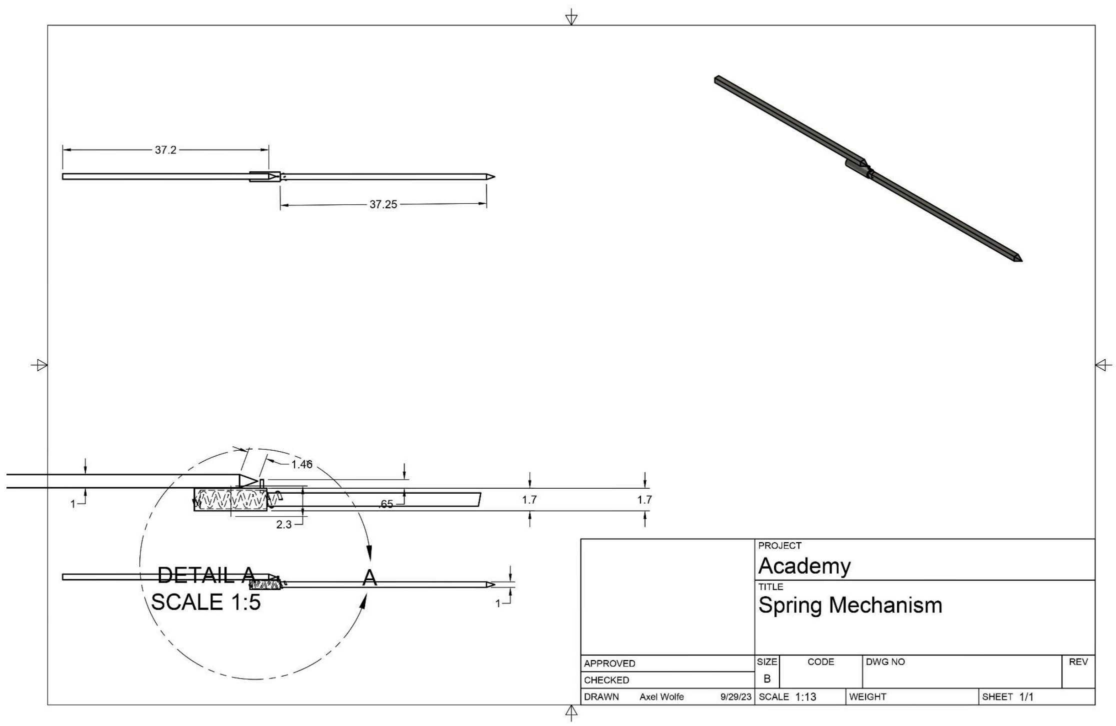


Fig. 15 Activity 2-6

The rod is made of wood. Each rod has a conical nose that pushes the spring latch rotationally, allowing the spring to be released in the subsequent “rod activity”. The spring latch will be purchased online as a whole piece.

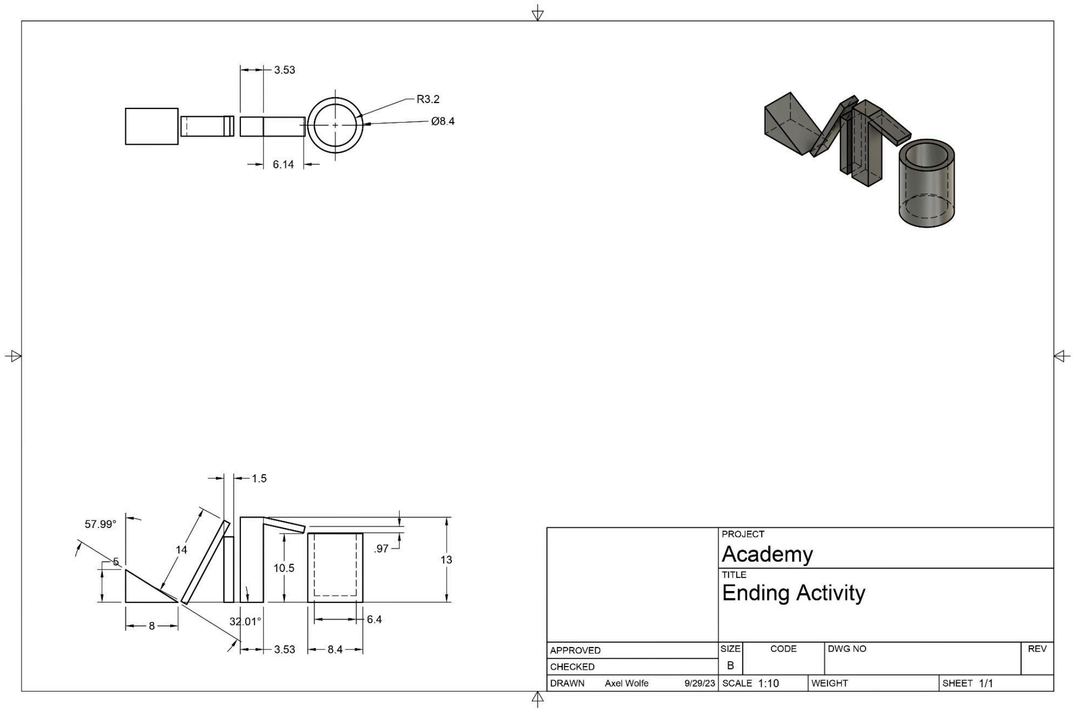


Fig. 16 Activity 7

These blocks are made of wood. When the triangular leftmost block is pushed forward, the block to the right will elevate. The crumpled paper sitting on top of that block will then be moved by gravity to roll down the ramp and into the trash can.

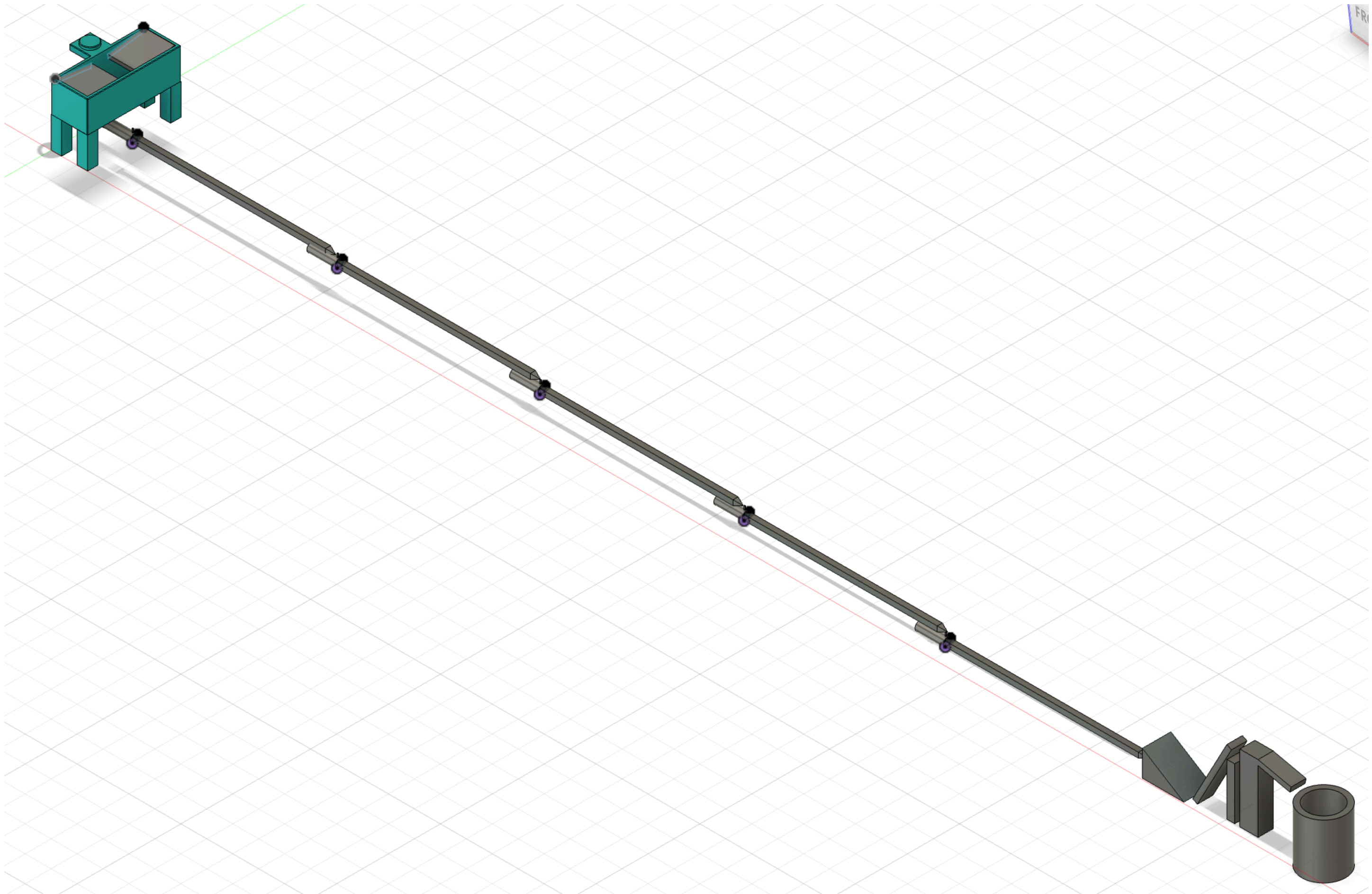


Fig. 17
Whole Prototype

In total, the prototype spans approximately 5 meters.

Cost Analysis:

Material	Description	Activity #	Quantity	Unit Price	Cost
Button and wires		1	1	N/A (already have)	$0
Wood Planks (18"x6")	(18"x6"x0.5")	1	7	$4/plank	$28
Spring Latch		2, 3, 4, 5	4	$5/latch	$20
Wooden Rods (37.25" long,	(40" long, 1" diameter)	2, 3, 4, 5	4	$2/rod	$8

Mini Bowling Ball		1	1	$10	$10
Labor to build prototype	Estimating approx. 4 hours to build first prototype	N/A	6 (people)	$15/hour	$360
Sandpaper, Superglue		2, 3, 4, 5	N/A	N/A (already have)	$0
					Total cost: $426

Equipment and Technology:

To build our prototype, we will need to model components in Fusion 360. We will then gather the necessary materials (as listed in the table above) to begin construction. We will start with constructing the "rod" activities first because this is the most important and difficult activity to perfect. We will construct dowels of the correct length using superglue to patch dowels together, create conical "noses" for each rod using sandpaper, and ensure that our spring latch trigger works as planned. Once the rods are finished, we will move on the first and last activities. The first activity requires us to build a small table-shaped platform, so we will use a saw to create correctly dimensioned pieces of wood, then use a nail gun or a hammer to connect all the parts. We will have a team member experienced with the button to correctly program the button. Lastly, we will use wood planks sawed to the correct dimensions to construct the last activity.

Component 3: Physics Analysis

Table of Activities:

Activity Number	Description of Activity	Energy Source	Energy Category	Weight (lbs)	Distance Traveled (inches)	Estimated Maximum Velocity of Object (ft/sec)	Product of Weight and Maximum Velocity (lb-ft/sec)
1	A wood panel is slid out, releasing two metal ball bearings. The balls fall through a PVC tube onto a switch.	Gravity	Gravity	0.016 lbs	1.7 ft	17.4 ft/sec	1.4 lb-ft/sec
2, 3, 4, 5	The switch pushed in the previous activity triggers a servo to rotate. A string connects the axel of the servo to the pin of a spring launcher. When the axel spins, the pin is pulled from the spring launcher and releases the spring from its compressed state. The spring pushes a small plastic ball down a pipe, which pushes another switch.	Springs	Springs	0.0004 lbs	3.9 ft	11.2 ft/sec	0.0045 lb-ft/sec
6	A crumbled paper ball rests on the farthest end of the conveyer belt. The switch pushed in the previous activity activates conveyer belt to turn. The piece of paper is carried horizontally down the length of the conveyer belt.	Electricit y	Other	0.04	1.25 ft	0.70 ft/sec	0.028 lb-ft/sec
7	The conveyer belt pushes the paper log into an angled cardboard tube. The tube is angled such that the paper will roll through the tube and fall into the wastebasket.	Gravity	Gravity	0.04	2.2 ft	4.4 ft/sec	0.176 lb-ft/sec

Equations:

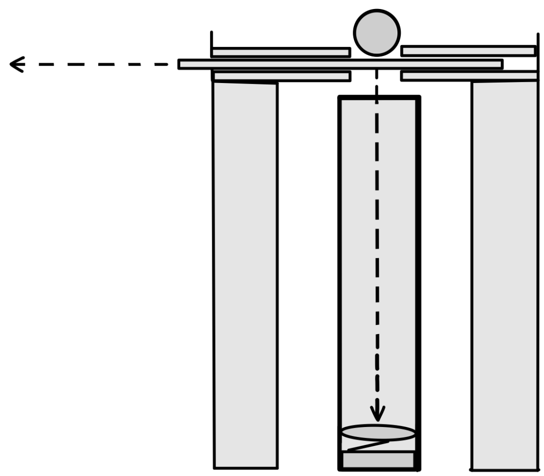


Fig. 18
Activity 1

The ball of mass M_B is initially at rest above the system. As shown in Figure 18, there is a barrier preventing the ball from falling vertically down distance D_T through a tube and onto a button. Once the barrier is removed to begin the activity, the ball will fall at an increasing velocity V_B with constant acceleration.

$$v^2 = v_0^2 + 2(a)(\Delta x) \qquad (1)$$

The ball has exclusively vertical displacement, so we can use the vertical components of its velocity and acceleration.

$$V_{By}^2 = V_{By0}^2 + 2(g)(D_T) \qquad (2)$$

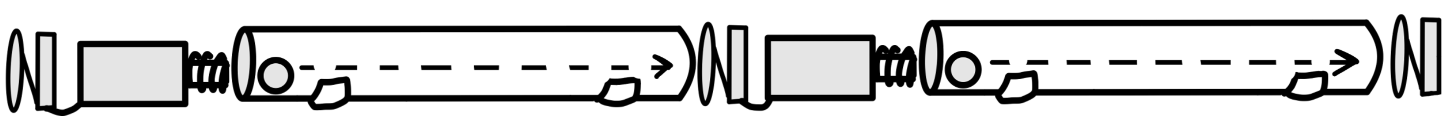


Fig. 19
Activity 2, 3, 4, 5, 6

The marble of mass M_M is launched through the tubes of length D_P by the compressed spring that is displaced by length X_S with a velocity V_M. Throughout the five repeated iterations of this action within Activities 2-6, The Law of Conservation of Energy states that energy is conserved with the exception of that lost to friction with coefficient μ of a Polyvinyl chloride (PVC) pipe. Note that the potential energy conserved is that of the spring.

$$\Delta U_S + \Delta K - \Delta E_{int} = 0 \qquad (3)$$
$$\Delta U_S + \Delta K - F_F - \Delta E_{int} = 0 \qquad (4)$$
$$\frac{1}{2}(k)(\Delta X_S)^2 + (\frac{1}{2}(M_M)(V_M)^2) - 0 = (\mu)(F_N)(D_P) \qquad (5)$$

Equation 5 can be algebraically rewritten to solve for V_M.

$$V_M = \sqrt{(\frac{2}{M_M})(\mu)(F_N) - \frac{1}{2}(k)(\Delta X_S)^2} \quad (6)$$

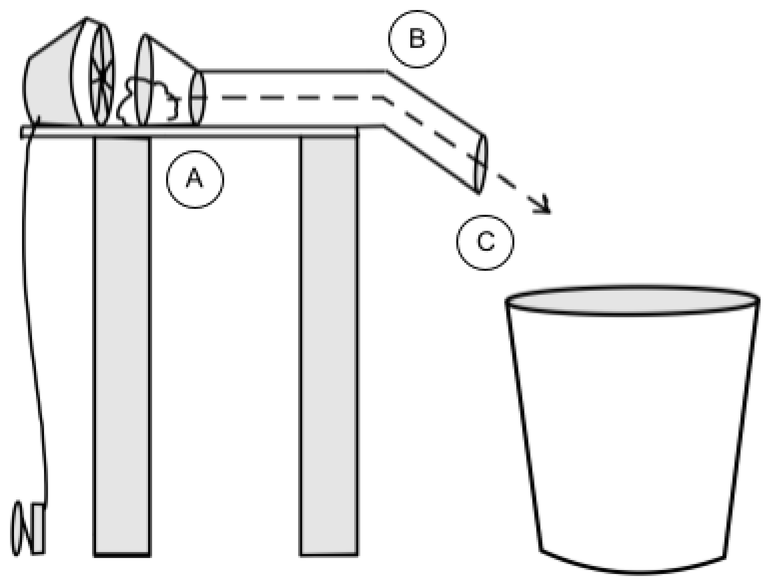


Fig. 20
Activity 7

The paper of mass M_P is at rest at point A. The fan positioned behind it turns on, producing wind that pushes the paper from Point A to Point B through a tube of length D_1 and with a force F_W, resulting in the paper's velocity to be V_{P1}. The paper then enters a ramp of length D_2 that makes an angle of -30° with the horizontal on which it moves from Point B to Point C with a velocity of V_{P2}.

To calculate the velocity of the paper from point A to B:

According to the Law of Conservation of Energy, energy is conserved in this activity with the exception of the energy that enters the system through $F_w(D_1)$ the energy that leaves the system due to friction.

$$\Delta U + \Delta K - \Delta E_{int} = 0 \quad (7)$$
$$\Delta U + \Delta K = F_W(D_1) - F_F \quad (8)$$

$$\frac{1}{2}(M_P)(V_{P1})^2 = (F_W)(D_1) + (\mu)(F_N) \quad (9)$$

Equation 7 can be algebraically rewritten to solve for the velocity of the paper at point B.

$$V_{P1} = [\, (\frac{2}{M_p})((F_W)(D_1) + (\mu)(F_N)\,]^{\frac{1}{2}} \quad (10)$$

To calculate the velocity of the paper from point B to C:

Observing Equation 3, energy is conserved except for the energy that leaves the system due to friction.

$$\Delta U + \Delta K - F_F - \Delta E_{int} = 0$$

$$[\, (M_P)(g)[-(D_2)\sin(\theta) - 0\,] + [\, \frac{1}{2}(M_P)(V_{P2})^2 - \frac{1}{2}(M_P)(V_{P1})^2\,] = (\mu)(F_N) \quad (11)$$

The normal force F_N takes into account the angle of the ramp.

$$F_N = (-F_G)(\cos(\theta)) \quad (12)$$

Substituting Equation 11 for F_N, Equation 10 can be algebraically rewritten to solve for the velocity of the paper at point C.

$$V_{P2} = \sqrt{(\frac{2}{M_p})[(\mu)(F_N) + \frac{1}{2}(M_p)(V_{P1})^2 - (M_p)(g)(D_2)sin\theta]} \quad (13)$$

Theoretical Device Performance:

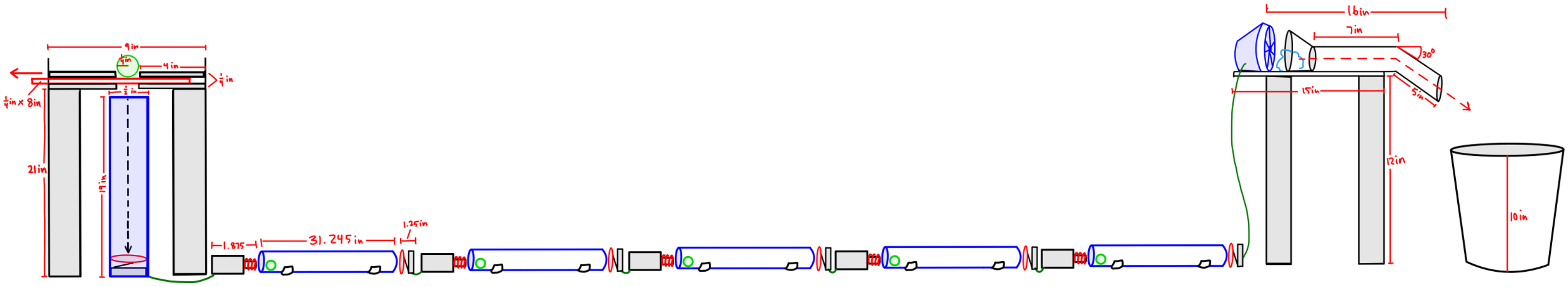


Fig. 21
Overall Device Geometry

Activity 1

D_T = -20 in

We input the values of D_T and the acceleration of gravity into Equation 2, making sure to convert from inches to meters.

$V_{By}^2 = 0 + 2(-9.8)(-0.508)$

This results in the magnitude of the ball's final velocity.

V_{By} = -3.3 m/s

Activity 2, 3, 4, 5, 6

M_M = 0.0084 kg
$F_N = (M_M)(g)$
D_P = 12.372 in
X_S = 0.025 m
k = 5 N/m
μ = 0.4

We input the values of M_M, X_S, and D_P into Equation 5, making sure to convert from inches to meters. We determined experimentally that the spring constant is 5 N/m. We established that the coefficient of friction of the PVC pipe is 0.4 as noted in https://www.vinidex.com.au/technical-resources/material-properties/pvc-properties.

$$V_M = \sqrt{(\frac{2}{(0.0084)}))(0.4)(0.0084)(9.8) \ - \ \frac{1}{2}(5)(0.025)^2)}$$

This results in the velocity at which the marble will hit the next button in each iteration of the activity.

V_M = 2.8 m/s

Activity 7

$M_P = 0.0045$ kg
$D_1 = 7$ in
$D_2 = 5$ in
$F_W = 0.028$ N
$\theta = -30°$
$\mu = 0.4$

We input these values into Equations 10 and 13, making sure to convert from inches to meters. The results show the velocity from Point A to Point B, and from Point B to Point C.

$V_{P1} = [\ (\frac{2}{0.0045})(0.028)(0.178) + (0.4)(9.8)(0.0045)\ ]^{\frac{1}{2}}$
$V_{P1} = 3.2$ m/s

$V_{P2} = [\ (\frac{2}{0.0045})[(0.4)(9.8)\cos(60°) + \frac{1}{2}(0.0045)(3.2)^2 - (0.0045)(9.8)(0.127)(\sin(-30°))]\ ]^{\frac{1}{2}}$
$V_{P2} =$ 29.7 m/s

Device Limitations:

Activity 1 requires the switch to be pressed with enough force to trigger it, meaning the initial height of the ball must be great enough to produce enough force from its acceleration due to gravity. If the ball is set at a greater height, then it will hit the switch with a greater velocity, but it will take longer to reach the switch. The height we chose is great enough for the ball to hit the switch with sufficient velocity, but short enough that the ball doesn't spend unnecessary time dropping.

Activity 2, 3, 4, 5 and 6 involve a marble being pushed through a pipe by the force of a spring. The marble's velocity relies on the type of spring—primarily its spring coefficient, k, and its displacement from a compressed state. The higher the k value or the greater the displacement, the greater the force the spring exerts on the marble. The spring we chose has properties that allow our marble's final velocity to be just under 3 m/s.

Activity 7 uses a fan to blow a crumpled paper ball down a ramp. The paper's velocity and displacement are dependent on the force of the wind, as choosing the highest fan setting will give the paper the greatest velocity, but it may be too powerful and overshoot, flying over the wastebasket instead of into it. Currently, this is the issue we are facing: with the fan we chose, the final velocity of the paper will be too high. We are working on procuring a fan whose wind speed ensures that the paper will predictably drop into the basket at a velocity just under 25 m/s.

Component 4: Build/Test

Build Progression:

Build Phase 1: Ball Drop

To initiate the build of our project, we started building the first activity of our device. We decided to construct the ball drop out of wood planks that we cut using the bandsaw, as well as a PVC pipe that the ball bearing would drop through. After all of our pieces were cut, we fastened them using a combination of wood glue, brackets, and screws (seen in Fig. 1). After completing the structure, we built a platform for the ball bearing to activate the limit switch as seen in Fig 2. This limit switch activates the first spring launcher by turning on the servo motor.

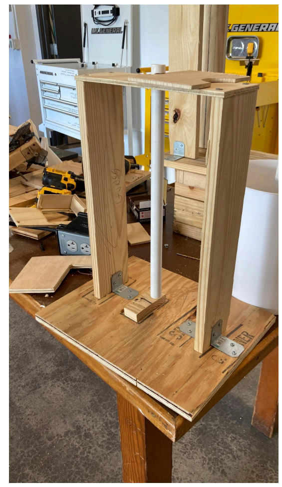


Fig. 1, Activity 1 Drop Structure

Fig. 2, Limit Switch

Build Phase 2: Conveyer Belt and Slide

After building the first activity, we decided to work on the end of our device by building the conveyor belt and slide. To build the conveyor belt, we stacked blocks of wood to create an elevated platform because it needed to be at least 15 inches off the ground. We then used wood glue to fasten the guide rails to the elevated platform. After assembling the wooden structure and guide rails, we drilled holes in the guide rails that housed the rotating axles (see Fig. 3). To finish the design, we attached the belt and the servo motor. Once the conveyor belt was completed, we created a sloped gravity slide that was attached to the end of the conveyor belt. We used pieces of wood to position the cardboard tube on an angle (see Fig. 4). The end of the tube was then positioned next to the waste basket.

Fig. 4, Cardboard Slide

Fig. 3, Conveyor Belt

Build Phase 3: Circuit Design and Spring Launcher Build

Once the first and last activities were completed, we proceeded to design the trigger mechanisms that would power our device. We modeled a basic circuit on a small breadboard that consisted of a limit switch and a servo, and once completed, we replicated the circuit four times. Then we modeled and 3d printed the mechanical spring launchers. Once all of these pieces were assembled, we drilled them onto the wooden platforms (see Fig. 5) that the rods would later connect to.

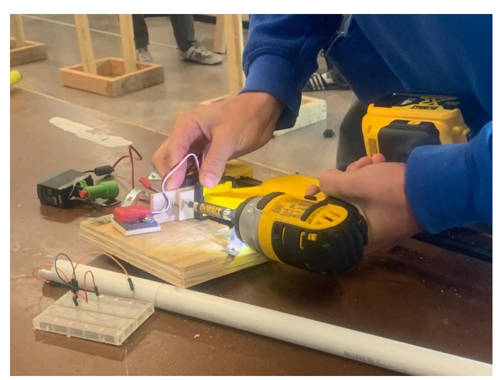


Fig. 5, Circuit and spring launch fabrication

Build Phase 4: Full Design Assembly

After the spring launch system was completed, we cut the PVC rods to equal lengths and used the bandsaw to cut notches on one end of each rod. We then attached the rods to the spring launch platforms and connected the breadboards to the limit switches and servos (see Fig. 6). Once we finished the assembly, we connected the circuits to power and began testing.

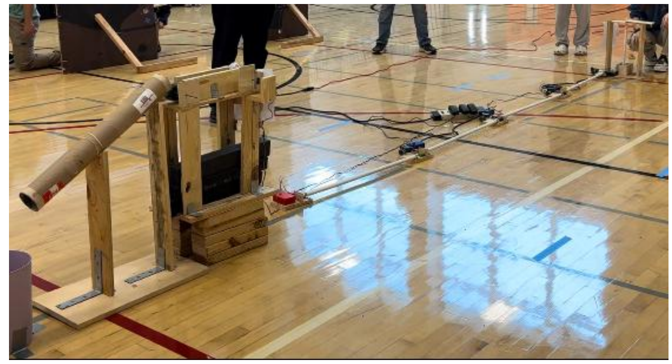


Fig. 6, Full Assembly

Test Criteria:

Criteria/Benchmark	Description of data needed	Quantitative or qualitative
Each activity must have an object that is displaced at least 15 inches horizontally.	Lengths of the distances traveled in each of our activities.	*Quantitative*
The speed of any object in the design must remain under 25ft/s.	Velocities of each moving object in the design.	Quantitative
Teams must set up their device in under 3 minutes.	Device setup time.	*Quantitative*
The paper must enter the basket.	Whether or not the paper enters the wastebasket.	*Qualitative*
The activity must fit within the 2m by 7m box, and start within the initiation area.	Whether or not the device fits the size constraints.	*Qualitative*

Testing Procedure:

1. Set up the device within the designated set-up area. The center of the wastebasket must be 5 meters away from the edge of the starting area, although the device may begin anywhere within the starting area.
2. Attach the rods to the attachment platforms and insert the pin into the spring launchers. Make sure to take the slack out of the string attaching the pin to the spool.
3. Place the red balls 2mm away from the end of the spring launch piston.
4. On “Go!”, pull the wood panel out and start the stopwatch.
5. Press “Lap” as each switch is triggered to record the completion times of each separate activity.
6. Once the paper enters the wastebasket, record the total time.
7. Repeat steps 4-6 times as necessary.

Component 5: Results/Conclusion

Testing Results:

Criteria/Benchmark	***Description of data needed***	***Quantitative or qualitative***	***Criteria/Benchmark pass or fail?***
Does each activity have an object that is displaced over 15 inches?	Measure the distance between the start to the end of each individual activity.	Quantitative	Pass
Does the speed of the object remain under 25 ft/s?	Measure distance from point A to B and measure the time that elapses as the object moves from point A to point B.	Quantitative	Pass
Does each metal and plastic ball activate the subsequent limit switch?	Activate the device, and observe as the balls move throughout their respective PVC pipe tubing. Record if each plastic ball activates the next spring launcher, and note any changes in design.	Qualitative	Pass
Is the speed of the conveyor belt optimized?	Measure the distance from the start of the conveyor belt to the end, and measure the time elapsed as the paper ball moves through the conveyor belt. Note any changes in conveyor belt design.	Quantitative	Fail, however included in final design due to time constraints.
Is the speed of the ramp optimized?	Record the time it takes the paper ball to fall through the ramp after it passes through the conveyor belt. Note any increase/decrease the angle of the ramp for slower/faster falling, keeping in mind the required 15 inches of distance.	Quantitative	Fail, however included in final design due to time constraints.
What is the speed of the device as a whole?	Measure the time it takes for the paper ball to fall into the ramp after the device begins to run. Note any critical malfunctions in device performance and/or changes made to optimize device speed.	Quantitative	Pass, however, could be improved.

Conveyor Belt Testing

Trial	Result (sec)	Notes
1	**0.571**	Paper positioning way off.
2	**0.456**	Possible human timing error.
3	**0.562**	Gear ratio increased.
4	**0.421**	N/A
5	**0.352**	Paper positioning *possibly* off.

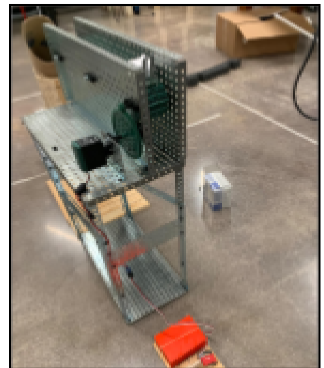


Fig. 1

Final Note: We were unable to increase the gear ratio of the conveyor belt past one layer due to the VEX DC motor's inability to handle the increased torque. There are also concerns as to the battery pack's ability to continue to supply voltage to the motor as the conveyor belt motor experiences significantly more stress than the other pin-pulling motors.

Ramp Testing

Trial	Result (sec)	Notes
1	**0.620**	N/A
2	**0.422**	Angle increased, length changed to compensate.
3	**0.418**	Human timing error.
4	**0.433**	N/A
5	**0.429**	N/A

Final Note: The ramp still remains the slowest of our activities by far. However, due to time constraints and lack of (willing) manpower we cannot easily remove/replace the ramp. Therefore, the current "optimized" state will have to suffice as we prepare for JPL.

Device Timing

Trial	Result (sec)	Notes
1	**DNF**	Device failed to complete full run.
2	**DNF**	Paper ball fell out of the ramp.
3	**4.10**	Possible human error.

4	**3.12**	Slow pin-out, fixed.
5	**2.83**	Out of time.

Final Note: While device performance has improved substantially thanks to efforts to optimize inefficient activities, there still remains much room for improvement. Unfortunately, due to poor work habits (on all group members' parts) there is not enough time to continue with optimization. The prototype design remains final as of 12/7.

Prototype Evaluation:

Reflecting on our device's performance and the feedback we have received from our peers and instructors, we consider our design solution to be a success. While our design may not have been the most visually appealing, it was capable of completing each activity reliably and produced a competitive time when tested at JPL.

It is worth noting that even though the build quality of our device was reliable enough to pass our testing procedures and hold through our competition, it was not sufficient aesthetically nor structurally. Several components of our design had to be redesigned or scrapped outright– not because of inherent inefficiency with the concept, but instead because of such poor construction. The conveyor belt was a good example of this– due to embarrassingly poor attention to detail, one of the original wooden stands fell off of the main body during setup at qualifiers. This prompted a complete redesign of the conveyor belt, including a complete metal chassis and gear ratio to increase its speed. Other noteworthy flaws in our construction included screws visible through the sides of wood, irregular wood heights and lengths, misaligned joinery, and an overall lack of consistency within many of the repeating structures.

While these flaws may not reflect a failure in our device's efficiency nor its results, they are telling signs of an overall lack of professionalism from all members of our group. Therefore, while our device's performance may be considered a success, the efforts of our group cannot be held to such regard.

Reflection Questions:

- Do the results reflect a problem with the materials used for the prototype?
  The results do not reflect a problem with the materials used for the prototype. There was no critical structural malfunction within our device during our testing procedures, that is, no component of our device collapsed or otherwise failed to complete its objective due to the material it was composed of during testing. Because our device did not experience any structural malfunction during our testing, the results do not reflect a problem with the materials used for our prototype.

- Do the results reflect a problem with the quality of the building process of the prototype?
  The results do not reflect a problem with the quality of the building process of the prototype. Although there were several concerns regarding build quality during the building process of the device, the device

did not experience any structural damage nor any major malfunction during the testing process. Once each component was stabilized, the device was able to consistently complete its objective (a "full run"). Because our device did not experience any problems regarding build quality during our testing, the results do not reflect a problem with the quality of the building process of the prototype.

- Do the results reflect a problem with the design of the prototype?
  The results do not reflect any *inherent* problem with the design of the final prototype. Every activity within our design has been tested to standard and has been improved to increase its efficiency– notable examples include the conveyor belt, ramp, and the pullout motors for the spring launchers. Each improvement has decreased the total time it takes for the device to complete its goal. The results reflect not a problem with the design of the prototype, but rather an account of the improvements made to each individual component. In its current state, the device is as fast and efficient as it has ever been. Therefore, the results do not reflect a problem with the design of the prototype.

Low Expectations
Santa Monica High School
Team Number 37

Activity Number	Description of Activity	Energy Source	Energy Category	Weight (lb)	Distance Traveled (ft)	Estimated Maximum Velocity of Object (ft/s)	Product of Weight and Maximum Velocity (lb-ft/s)
1	A wood panel is slid out, allowing two metal ball bearings to fall through a tube and onto a switch.	Gravity	Gravity	0.016 lb	1.7 ft	17.4 ft/s	1.4 lb-ft/s
2, 3, 4, 5	A string connects the axle of a servo to the pin of a spring launcher. The switch pushed in the previous activity triggers the servo to rotate. When the axle spins, the pin is pulled from the spring launcher and the spring within is released from its compressed state. The spring pushes a small plastic ball down a pipe. The ball hits a switch.	Spring	Spring	0.0004 lb	3.3 ft	12.7 ft/s	0.0051 lb-ft/s
6	A crumpled paper ball rests on the farthest end of the conveyor belt. The switch pushed in the previous activity activates the conveyor belt. The paper is carried down the length of the conveyor belt.	Electricity	Other	0.04 lb	1.25 ft	2.7 ft/s	0.11 lb-ft/s
7	The conveyor belt pushes the paper ball into an angled cardboard tube. The paper rolls through the tube and falls into the wastebasket.	Gravity	Gravity	0.04 lb	1.25 ft	5.7 ft/s	0.23 lb-ft/s