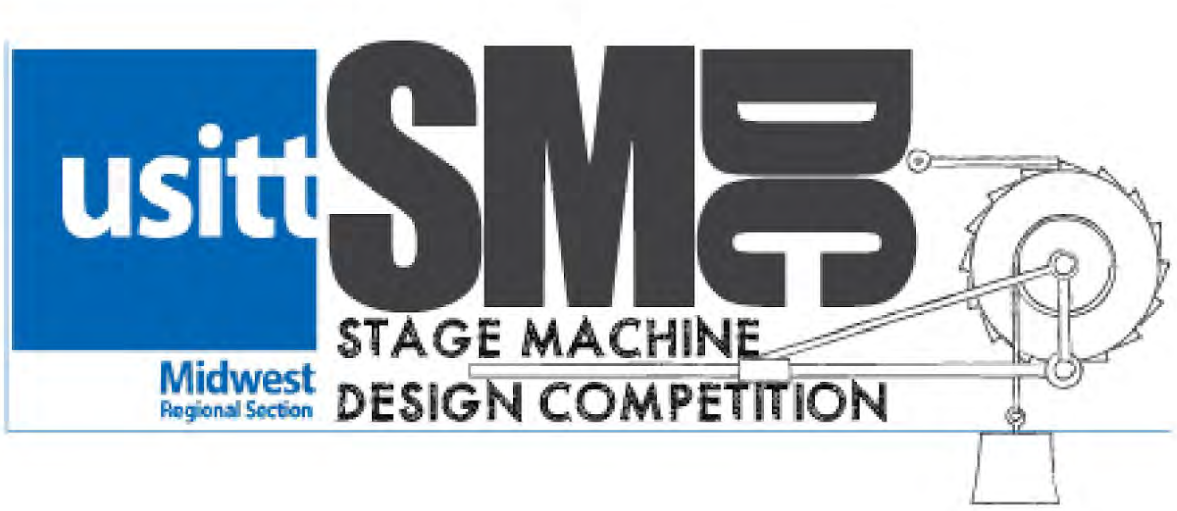

2019 Midwest Stage Machine Design Competition Design Proposal

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Design Specification and Concept Generation

Design Specification

This design was created as a petal drop mechanism for an upcoming production of *Much Ado About Nothing.* The machine must be designed to function at center stage, scattering petals with a maximum diameter of 3 feet. The petals must fall gently, slowly, and continuously for about 30 seconds from a height of 15 feet above the actors. The machine itself cannot take up more than a 20 inch by 20 inch space on a 1.5" batten. The device, once installed, cannot be lowered, and must be reloadable from the ground in ten minutes or less. The effect must be operable by a stagehand sitting 25 feet offstage of the device, and must be relatively silent to run under a soft music score. The production team is interested in a device that can be reusable for other, similar drop effects.

It is important that any and all stakeholders are taken into account throughout the design process. These stakeholders include, but are not necessarily limited to, the technical director, director, stage management, actors, producers, crew, audience, sound designer, the lighting team, and the manufacturers for the parts we have chosen.

Research

The concept design phase started with research of existing devices currently for in use for falling snow or leaf effects. Some of these products and designs included the following:

- Snow cradle constructed using Muslin with holes attached across two battens. The battens are moved so the materials fall through the muslin ("How to Make a Snow Cradle")
- Limelight Productions Snow effect suggestions ("Let It Snow!")
- Control Room chat room for falling snow ("Snow?"*)*
- Reddit discussion about falling leaves ("r/Techteatre…")
- Rotating disk used to distribute snow in a production of A Christmas Carol (Coakley)
- Rosebrand Snow Tumbler (Rosebrand)
- Control Room chat room for raining leaf effect ("How to make it 'Rain' Flowers?")
- DYE Rotor feed mechanism used in paintball guns (ANSgearPaintball)

Concept Generation and Evaluation

Additional brainstorming resulted in many rough concept designs. The first of these consisted of a five gallon bucket with holes drilled into the bottom. A fan would then be attached to the top of the bucket, blowing the petals out of the bottom (see **Figure 1**). The second of these designs was a simple wooden frame attached to a mechanism which would shake, causing the petals to fall through (see **Figure 2**). A similar design consisted of a milk crate which would also shake from side to side, causing petals to fall out as it moved (see **Figure 3**). The third rough design consisted of a tube filled with flower petals which used a linear actuator to push the petals out through an opening at one end (see **Figure 4**). Finally, the last of the rough designs added rotating blades, similar to the dye rotor feed mechanism from the initial

concept research, to toss the petals into a funnel before they fall through a small hole in the bottom of a five gallon bucket (see **Figure 5**).

To decide which of these concepts was the most worth pursuing, a weighted decision matrix was used to evaluate four concepts: a five gallon bucket with small rubber arms to push petals outward, a five gallon bucket with rotating blades and a funnel, the typical snow drum, and the rotary actuator. The decision matrix evaluated factors such as weight, cost, build feasibility, ease of use, and ability to meet the design specifications (see **Figure 6**). Concept 1, a five gallon bucket with a funnel and small arms to push the petals as ultimately chosen because of the ease with which flow rate could be altered, as well as the simplicity with which it could be reloaded.

The loading device was designed to be simple and user-friendly. It is made using an upside-down paint bucket attached to an extendable arm. The paint bucket turned right side up, then is loaded with petals. The magnetic lid to the paint bucket is then shut, then the arm is extended, and the lid is reopened over the main petal drop device via a line of aircraft cable, which loads the petals to be dropped (see **Figure 7**).

The most challenging aspect of this design has been the meeting the design specification of a 3’ diameter fall area for the effect. Testing was performed on how petals fall from a 15’ height by pushing them through a 1” hole, dropping them in a single condensed ball, and controlling a gradual fall. The 1” hole yielded the smallest fall diameter of 8’ while the other options resulted in about 12’ diameters. These tests can be seen via the link provided in the Appendix (see **Link 1**). The chosen design we chose best mimics the 1” hole drop, as the flower petals are pushed through a hole in the bottom of the bucket. Other steps will have to be taken to control the fall diameter.

Build Progress

Our loading device is completely built and operable. We originally intended to provide a guide for the aircraft cable stretching to the lid of the device using fishing rod eyelets. The epoxy used to secure these was unsuccessful so we will need to generate more ideas about how to guide the cable (see **Figure 9** and **Figure 10**).

The wiring for the motor and gears is complete (see **Figure 11** and **Figure 12**). A wired control box was constructed with the ability to turn the motor on and off as well as control the speed of the motor using a potentiometer (see **Figure 13**). The arms were attached and the device was successfully tested inside the bucket. Flower petals were able to pass through the device with little trouble.

Future Improvements

With the current design of pushing flower petals through a 1” hole, the tested fall diameter is about 8 ft. Another concept to combat this wide fall radius would be to create a column of air that contains the fall of petals for as long as possible. Using geometry, the distance of the column of air was determined to achieve the desired 3’ fall radius. This is assuming the fall of flowers is linear. Calculations found in **Figure 14** yielded that the air column must reach to about 5’ 5” above the floor in order to achieve the

desired diameter. This would be fabricated using a 3D printed air channel that receives air and expels it in a circle below the bucket, which would sit inside the inner ring of the printed piece (see **Figure 15**). The channel would be fed by three air hoses surrounding the bucket. The intention of this is to have evenly distributed air flow through the channel. The air pressure would need to be tested at a gentle level that keeps the air flow quiet and safe. The plastic required to print this part should be around $3 and the extra hose hardware will be about $6.

There is currently not a specific design for attaching the device to the batten. Future testing will reveal if the mechanism is stable enough for the bucket to simply hang by the handle and held in place by a cheeseborough. **(Figure 16)** Modifications may need to be made depending on if this will get in the way of the loading device. This should be of little cost, assuming hardware can be borrowed from the shop.

In order to shield the motors and gear train from the petals and guide the petals to the exit of the device, a funnel will need to be added inside the bucket. The intention is to CNC cut four sides of a funnel and secure them inside the bucket. **(Figure 17)** This should not add any cost to the final design as scrap plywood will be used. For future designs, it is recommended to also shield the gears with a mesh that keeps the petals from getting caught. This current prototype will not have this feature. This could cost around $25.

Loading Device Manual/User Instructions

Introduction

This device is intended to load an open ended basket at a max height of 17 feet with a user's intended material. This device allows the user to stay on the ground and load the basket without having to climb up to it or bring it down.

This device is comprised of three main parts: Flagpole, Capsule, and Cable. The capsule holds the intended deposited material. On the capsule, there is a lid hinged to open and shut nicely. The lid is held to the capsule by magnets to stay close when needed but also to be pulled apart with minimal force. The capsule is attached to a flagpole that can extend up to 17 feet. The flagpole's minimal length is 4' feet which allows the device to be stored easily. A cable runs from the capsule's lid to the base of the flagpole. To open the lid when the capsule is in place, the cable must be pulled.

Safety

- Material intended to be dropped is up to the user's discretion.
    - Loading device is designed to hold a maximum of 5 lbs of additional weight.
    - Do NOT fill with sharp or heavy objects. In the possible case that the lid will open before the cable is pulled or the cable is pulled when the capsule is not lined up, the material will fall and possibly cause injuries depending on material.
- Minimal force is needed to pull the cable when action is needed. If cable is pulled with extreme force, flagpole will become unsteady and hard to control.
- Be sure all layers to the flagpole are in the locked position. Test if each layer is locked before continuing to open next layer. If layer does not lock, capsule may slide down causing a small crash making the flagpole hard to control and possibly losing contents in the capsule.

- Minimize movement when flagpole is fully erect. This will cause the flagpole hard to control and possibly lead to losing contents in the capsule.
- When not in use, store the device with the flagpole fully closed.

Set Up and Instructions for Use

1) Open the lid to the capsule with opening facing up.
2) Fill the capsule with material intended to be deposited.
3) Close the lid making sure the magnets are aligned.
4) Slowly, extend each layer of the flagpole while unraveling the cable. To extend, twist the layer until it's unlocked, pull out, the twist to lock. Start with the top most layer of the flagpole moving down towards the base until desire height is achieved.
5) Slowly lift the end of the flagpole from the base with minimally twisting of the pole.
6) Position the capsule directly above the deposit basket.
7) When flagpole is steady and capsule is above the basket, with controlled force, pull the cable directly down.
8) Wait until all material is deposited then slowly bring the flagpole away from the basket.
9) Lower the flagpole to the horizontal position that it was at before lifting.
10) Refill capsule if more material is wanted/needed in basket.
11) Repeat steps 5-10 until basket is filled to desired height.
12) Starting from the base, twist each flagpole layer until it is unlocked. Push layer back into the base then twist to lock. Keep doing this until the flagpole is closed.
13) Close the lid to the capsule.
14) Store device in a safe area.

Maintenance

Capsule/Lid

- Lubricated hinges every time before or after use.
- Tighten carabiner connection of cable and lid before each use.
- Apply epoxy when it appears to be fading.

Cable

- Coil when not in use.
- Check for kinks in the wire rope - too many kinks should be replace.

Flagpole

- Examine the flagpole's warpness from carrying weight after every use
    - If the deflection is noticeable to the eye, replace the flagpole

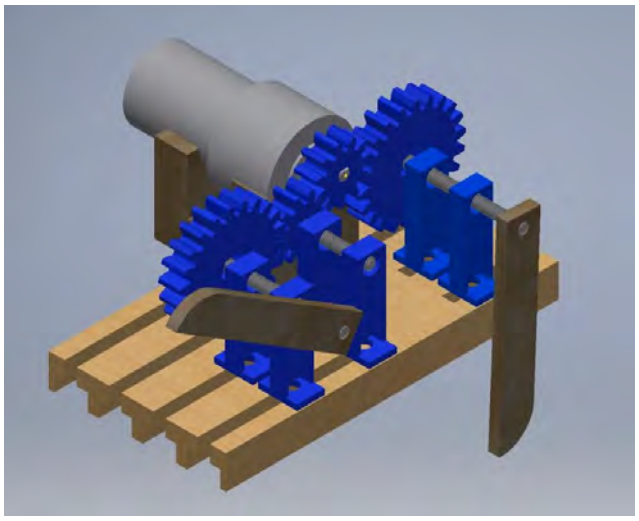
Troubleshooting

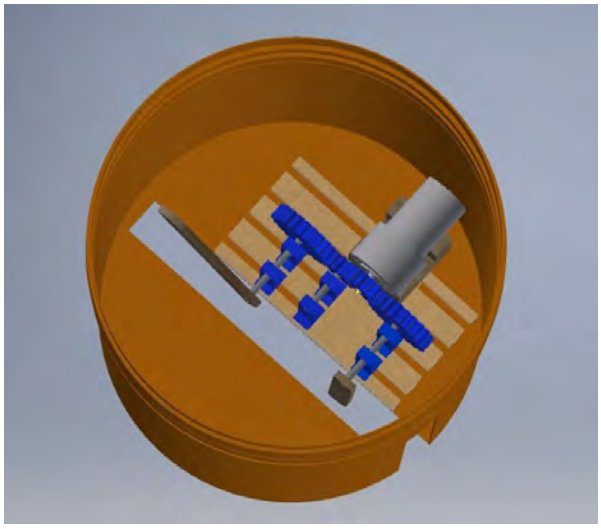
- PROBLEM: Contents keep falling out
    - SOLUTION: Something might be blocking magnets
    - SOLUTION: Lower the weight of material loaded each time
    - SOLUTION: Minimize the amount of movement when loading
    - SOLUTION: Examine the lid making sure the magnets are still connected
- PROBLEM: Flagpole will not open/close
    - SOLUTION: Twist the layer until is becomes loose/sturdy
- PROBLEM: Lid won't open
    - SOLUTION: Pull the cable directly down with great force
    - SOLUTION: Examine the capsule making sure there is nothing holding it down
- PROBLEM: Cable tangles
    - SOLUTION: Untangle the cable
    - SOLUTION: Keep the cable straight when in use and coiled when not in use

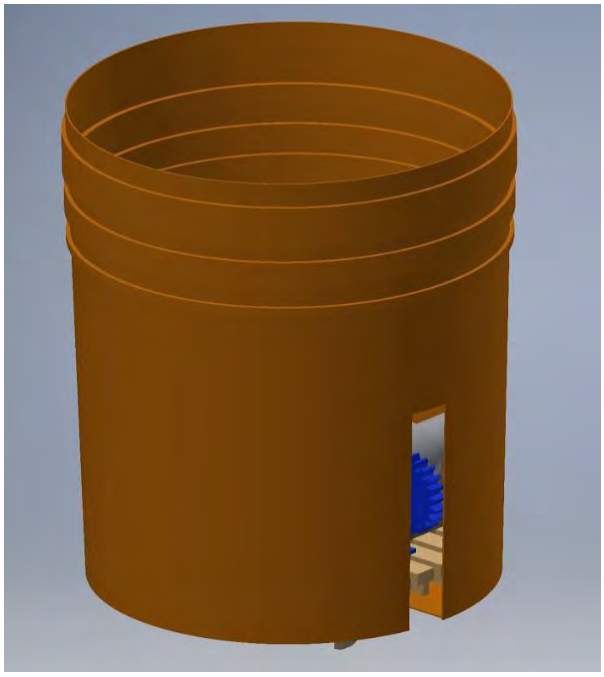
Motor Control Manual/User Instructions

Introduction

This component of the mechanism comprises the motor, gear reducer, and control system that is used to regulate the flow of petals. The system is to be installed in the bottom of the bucket, and the wire connecting to the control box will be attached to the batten, tracking off stage before dropping to the floor of the wings, where the operator will have control of turning on the effect and modifying the speed of the motor (see **Figure 8** for a more detailed wiring diagram).







Safety

- Material intended to be dropped is up to the user's discretion.
    - Do NOT supply voltage to the system exceeding 12V DC.
- When disconnecting bullet leads, ensure to grasp connects by vinyl sheath, so to avoid exposing wires
- Do NOT exchange gears in the gear drive when power is connected to the system

Set Up and Instructions of Use

1) Open back panel of the control box, ensure that wiring is accurate to wiring diagram
2) Connect wires to motor
    a) Run motor to ensure polarity is correct, if device is running backwards, switch terminals
3) Bolt gear plate to bucket and attach bucket to batten
4) Attach wire to batten using tie-line

Maintenance

Motor

- Visual inspection of soldered joints, re-solder if needed
- Visual inspection of bullet leads, replace if needed

Electronics

- Coil wire when not in use.
- Visual inspection of soldered joints, re-solder if needed
- Visual inspection of bullet leads, replace if needed

Gear Train

- Examine gears, replace if cracked

Troubleshooting

- PROBLEM: Motor won't spin
    - SOLUTION: Check for sources of excessive resistance
    - SOLUTION: Check Voltage output of batteries
        - Should be 12V to run at capacity
    - SOLUTION: Inspect soldered and bullet lead connects

Failure Mode Effects Analysis for Loading Device

Item	Requirements	Failure Mode	Failure Effects	Potential Cause	Current Prevention	Recommended Action
Capsule lid.	Open after cable is pulled to release petals.	Lid opens before the cable is pulled.	Petals fall prematurely and potentially miss the bucket.	Weak magnet connection.	Use a strong enough magnet to hold the lid in place before pull.	Bring the capsule down to determine the problem.
		Lid does not open when pulled.	Petals do not fall into the bucket.	Magnet connection is too strong to be pulled apart.	Buy a magnet that is weak enough to pull apart.	Use a different magnet.
		Handle detaches when the cable line is pulled.	Cable cannot pull the lid to release the petals.	Magnet connection is too strong, using too much force to pull the cable, or screws rip out.	Use the right magnets, only pull with the force needed to release the petals, and use the right size screws for this application.	Bring the capsule down and fix the problem.
		Hinge breaks off.	Lid completely falls off of the capsule.	A large amount of force is applied to the cable after the capsule is open.	Only pull the cable enough to release the petals.	Bring the capsule down and reattach.
Capsule Attachment.	The capsule attaches to the flagpole.	The capsule becomes detached from the flagpole.	The capsule becomes detached and could fall to the ground.	The attachment is not secure or too much force is applied to the cable.	A secure attachment is made between the capsule and the pole.	Shout "heads" if the capsule falls. Bring down the capsule and repair.
Item	Requirements	Failure Mode	Failure Effects	Potential Cause	Current Prevention	Recommended Action
Flagpole.	Extends to position the capsule over the petal drop device.	One of the extension locks becomes loose and falls.	A portion of the pole falls, potentially pinching fingers.	The lock was not twisted all the way.	Tightly twist the lock after extending.	Re-extend the pole. If the lock is broken, a new pole may have to be purchased.
		The pole is bent out of shape.	The capsule may not reach the petal drop device or may be difficult to control.	Large top heavy loads.	A flagpole should be able to hold a fair amount of weight and remain sturdy when extended.	A new flagpole may need to be purchased.
Cable.	Pulled by the operator to open the capsule lid and release the flowers.	The cable becomes tangles.	The cable may become misaligned. Becomes hard to open the lid.	Moving the flagpole too much.	Keep flagpole straight when in the air.	Untangle the cable.
Magnets	Holds the lid to the capsule.	Magnets fall of the lid or the capsule.	Lid no longer closes resulting in petals fall out.	Epoxy breaks.	Use the right amount of epoxy and mix correctly.	Re-epoxy or use a different adhesive.
Epoxy	Holds the magnets to the lid/capsule, the blocks to the flagpole, and the eye screw to the lid.	Epoxy breaks.	Magnets fall off, extension blocks loosen, eye screw loosen	Epoxy not applied well, mixed correctly, or on a surface that does not hold epoxy well.	Apply epoxy liberally and mix it correctly.	Re-epoxy or use a different adhesive.
Item	Requirements	Failure Mode	Failure Effects	Potential Cause	Current Prevention	Recommended Action
Screws	Holds the hinges from the capsule to the lid.	Screws breaks.	Lid detaches from the capsule.	Too much shear on the screws.	Multiple screws holding the hinges.	Add more screws or replace used screws.

Hinges	Allows the lid to be attached to the capsule and allows the lid to open/close.	Hinge won't move.	Lid won't close or open.	Hinge is not lubricated.	Maintenance hinge properly.	Lubricate hinge.
		Hinge breaks off.	Lid completely falls off of the capsule.	A large amount of force is applied to the cable after the capsule is open.	Only pull the cable enough to release the petals.	Bring the capsule down and reattach.
Hinge Block	Allows Hinge to connect to capsule with maximum movement.	Block breaks.	Hinge disconnects from capsule.	Too much bending or shear on the block.	Appropriate amount of weight acting on the block.	Replace the block.
Eye Screw	Allows the cable to be connected to the lid.	Eye screw breaks.	Cable is no longer attached to the lid.	Too much force pulling the screw.	Pulling the cable with the right amount of force.	Replace the eye screw.
		Eye screw is pulled out.	Cable is no longer attached to the lid.	Too much force pulling the screw.	Eye screw is screwed into the lid and is held with epoxy.	Put the eye screw back into the lid with a new hole.
Item	Requirements	Failure Mode	Failure Effects	Potential Cause	Current Prevention	Recommended Action
Carabiner	Holds the cable to the eye screw.	Carabiner breaks.	Cable is no longer attached to the lid.	Too much force pulling the carabiner	Pulling the cable with the right amount of force.	Replace the Carabiner.
		Carabiner lets go of the cable/eye screw.	Cable is no longer attached to the lid.	Carabiner not closed all the way.	Carabiner tightly closed.	Reapply the Carabiner and close tightly.
Flagpole blocks	Holds the capsule to the flagpole.	Blocks break.	Capsule no longer attatch to the flagpole.	Too much force acting on the blocks.	Limiting the amount of weight is in the capsule.	Replace the block.
		Blocks slip.	The capsule slides down.	Zip ties are not tight enough or epoxy breaks.	Zip ties are tighten and epoxy is applied.	Replace zip ties or reapply epoxy.
Zip ties	Keeps the flagpole blocks from sliding.	Zip ties break.	The capsule slides down.	Too much force in acting on the zip ties.	Limiting the amount of weight is in the capsule.	Replace zip ties.
		Zip ties slip.	The capsule slides down.	Zip ties are not tight enough.	Zip ties are pulled tight.	Replace zip ties.

Failure Mode Effects Analysis for Motor and Control

FMEA - Motor and Control

Part	Failure Mode	Cause of Failure	Effect of Failure	How should this be dealt with?
Motor	Soldered Joints disconnect	Wires are yanked	Loss of power to motor	Carefully wire the device and do not yank wires
	Bullet Leads Disconnect			
	Motor Burns Out	Motor unable to overcome resistance torque	Loss of motor function	Ensure motor is unlikely to get caught by pedals/bucket
Wires	Wires overheat	Excessive voltage is supplied to the system	Loss of control of motor	Do not supply greater than 12V of DC power to the system
			Potential fire hazard	
Drive Gear	Gear falls off of shaft	Press-fit loses its fit	Loss of contol of effect	Consider permanantly fixing drive gear to shaft
	Gear Shatters	Significant torque on gear		Ensure the system is not subjected to excessive torque
Driven Gears	Gear Shatters	Significant torque on gear	Loss of control of effect	Ensure the system is not subjected to excessive torque
Driven Gear Shafts	Shaft Breaks	Extreme loading	Loss of control of effect	Everything else will fail before this, no action needed
Brass Bushings	Bushing fall out of Mounting	Press-fit loses its fit	Increased Friction on system	Consider permanantly fixing bearings to mounts
			Gears misallign, loss of control	
Bushing Mounts	Mounts Shatter	Extreme Loading/Shock load	Loss of control of effect	Ensure the system is not subjected to excessive loads
Mounting Plate	Mounting Plate Breaks	Extreme Loading/Shock load	Loss of control of effect	Ensure the system is not subjected to excessive loads
	Mounting Plate comes free from Bucket	Bolts come loose		Secure Bolts with Locktite/Teflon Tape
			Loose hardware overhead	
Petal Pushing Sticks	Sticks Break	Excessive torque on sticks	Loose Hardware overhead	Ensure sticks are not subjected to excessive loads
			Loss of control of effect	
	Sticks come loose	vibration/regular use	Loss of control of effect	Secure Bolts with Locktite/Teflon Tape

Cost and Parts Breakdown

Motor and Controls

Item	Vendor	Unit Cost	Quantity	Subtotal
1/4" -20 Threaded Rods	Lowes	$ 1.99	2	$ 3.98
1/4" ID Brass Bushings	Von Tobel	$ 0.56	8	$ 4.48
3mm PLA - 1 kg	Hatchbox	$ 19.99	1	$ 19.99
Greartisan DC 12V 100RPM Gear Motor	Greartisan	$ 15.49	1	$ 15.49
18 GA Speaker Wire - 100 ft	Lowes	$ 15.98	1	$ 15.98
Bullet Leads (5 Pair Pack)	Lowes	$ 2.58	1	$ 2.58
100 Ohm, 3 Watt Potentiometer	Mouser	$ 4.39	1	$ 4.39
AA Batteries - 8 Pack	Walmart	$ 6.94	1	$ 6.94
AA Battery Packs	Lafayette Hobby	$ 2.99	2	$ 5.98
Toggle Switch	Lafayette Electronics	$ 4.99	1	$ 4.99
			Total	$ 84.80

Loading Device

Part	Details	Part/Model Number	Supplier	Price per Unit	Number of Units	Retail Price	Donated?
Lid	1/4" Lauan	204853843	Purdue Univerity	$6.74	1	$6.74	Yes
Empty Paint Can	1 Gallon	HDPCN65D	Purdue Univerity	$14.97	1	$14.97	Yes
Flagpole	20' Max	FPFTG20	Flagpole-To-Go	$49.95	1	$49.95	No
Zipties	100 Pack, 8" Long	203531910	Purdue University	$7.45	1	$7.45	Yes
Hinges	2 Pack, 1" Zinc Plated - includes screws	202034166	Home Depot	$1.48	1	$1.48	No
Magnets	10 Pack, 1/2" Disc	203613121	Home Depot	$1.98	1	$1.98	No
Eye Screw	3 Pack, 1 3/8" Length	204281684	Purdue University	$1.18	1	$1.18	Yes
Flagpole Block	1x3	306896206	Purdue University	$4.94	1	$4.94	Yes
Aircraft Cable	1/16"	300018981	Purdue University	$11.24	1	$11.24	Yes
Hanger Strap	3/4"	100167964	Purdue University	$1.98	1	$1.98	Yes

Total Retail Price:	$101.91
Total Saved from Donations:	$48.50
Total Spent	$53.41

Appendix

Figure 1: Rough design 1, a bucket with multiple holes and a fan

Figure 2: Rough design 2, a shaking wooden frame

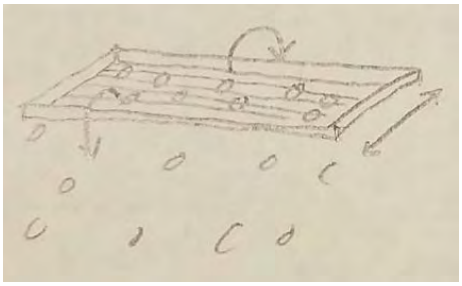


Figure 3: Similar to Rough Design #2, this design used a milk crate as opposed to a wooden frame

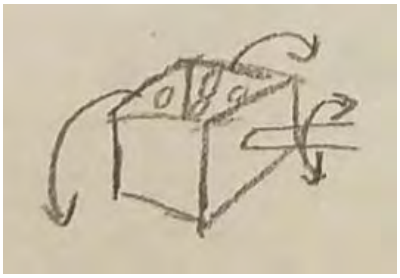


Figure 4: Rough Design #3, a linear actuator

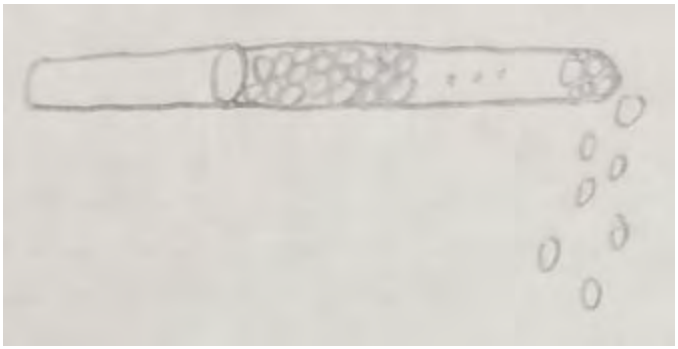


Figure 5: Rough Design #4, a five gallon bucket using blades and a funnel

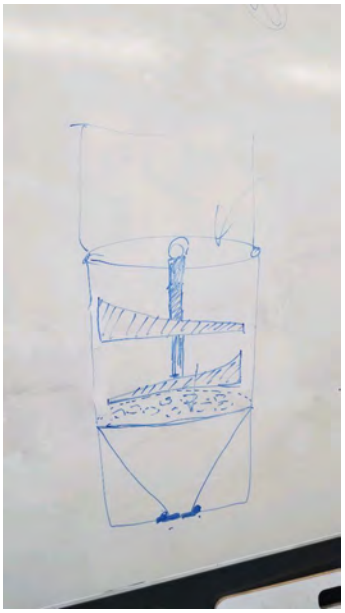


Figure 6: Weighted Decision Matrix

Concept 1:	Five gallon bucket with a funnel at the bottom ending with a small exit. Tiny motor with rubber arms at the exit to push out petals.
Concept 2:	Five gallon bucket with a funnel at the bottom ending with a small exit. Dye Rotor-like parts on the inside with "oh crap" arms at the exit.
Concept 3:	Normal snow drum. Cylinder with holes slowly rolling.
Concept 4:	Rotary Actuator

Criteria	Weight	C1	C1Weight	C2	C2Weight	C3	C3Weight	C4	C4Weight
3' dia fall	5	3	15	3	15	1	5	3	15
Continuous, gentle fall	5	5	25	4	20	5	25	4	20
Cost	5	4	20	4	20	4	20	4	20
Weight	1	4	4	4	4	3	3	4	4
Reloadable from the ground	5	5	25	5	25	1	5	4	20
Ease of Use	3	5	15	5	15	3	9	5	15
Elegance of Design	3	2	6	2	6	4	12	4	12
Ease of Installation	5	3	15	3	15	3	15	3	15
Feasible to build	3	4	12	2	6	4	12	3	9
Opterational from offstage	5	5	25	5	25	5	25	5	25
Reload in less than 10 mins	5	5	25	5	25	2	10	5	25
Quiet under soft music score	5	3	15	3	15	3	15	3	15
Use for other materials	2	2	4	2	4	3	6	4	8
Power/Air Restriction	4	3	12	3	12	5	20	4	16
Time Control (30s)	5	3	15	2	10	4	20	4	20
Set up time (30 min)	3	5	15	5	15	5	15	4	12
Flow rate control	3	5	15	4	12	5	15	3	9

Total	
Concept 1:	**263**
Concept 2:	244
Concept 3:	232
Concept 4:	260

Figure 7: The loading device

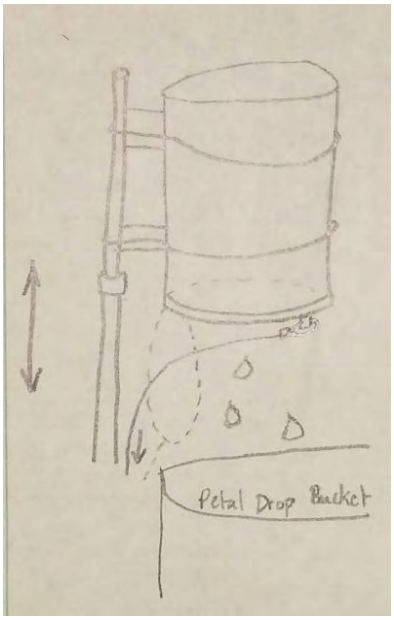


Figure 8: Wiring diagram for drop device

Figure 9: Loading device build progress

Figure 10: Original Cable Guides

Figure 11: Wiring for motor and gears

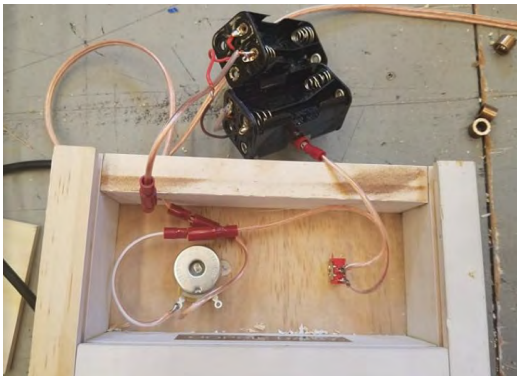


Figure 12: More wiring with motor and gears

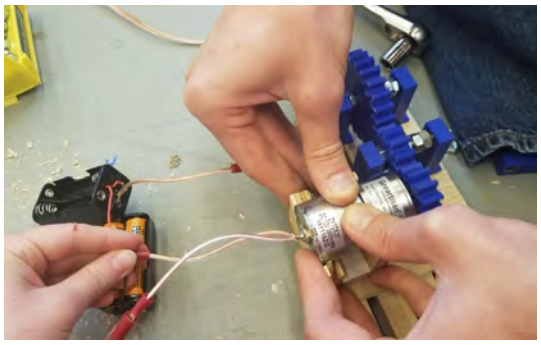


Figure 13: Box to control speed and turn machine on

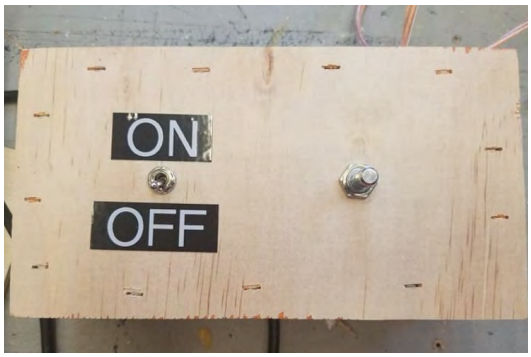


Figure 14: Air column Calculations

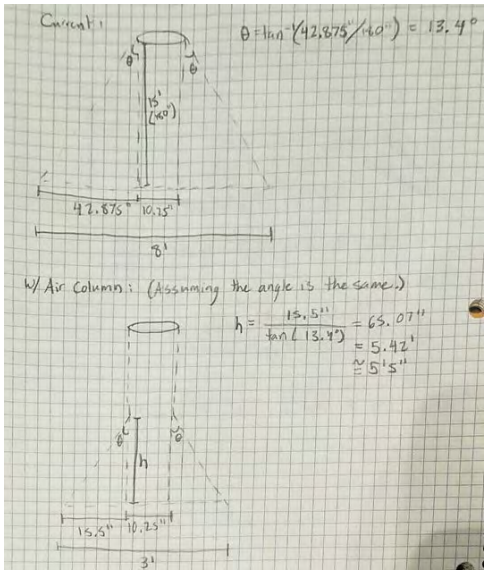


Figure 15: Model of what the “air column” printed piece would look like

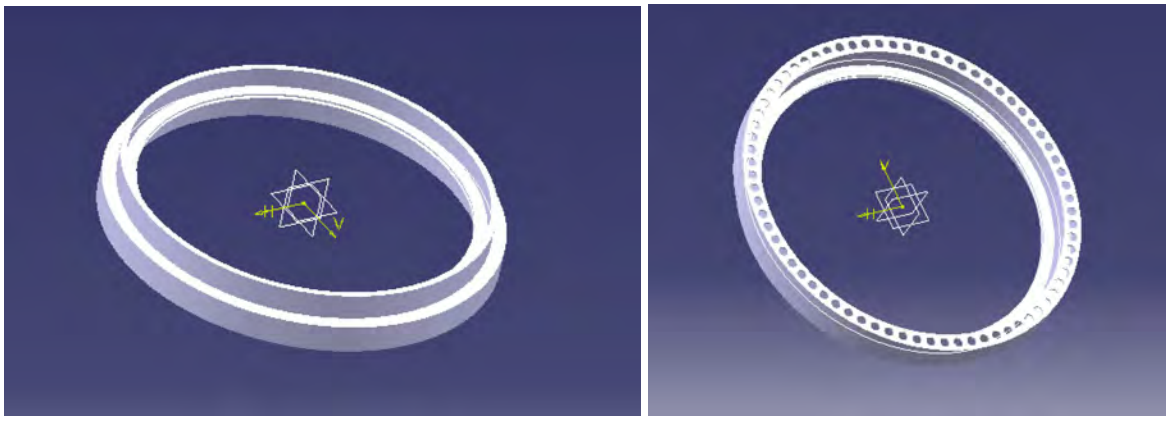


Figure 16: Batten Attachment

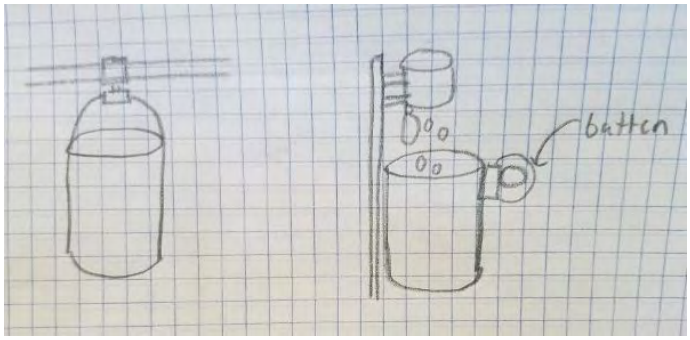
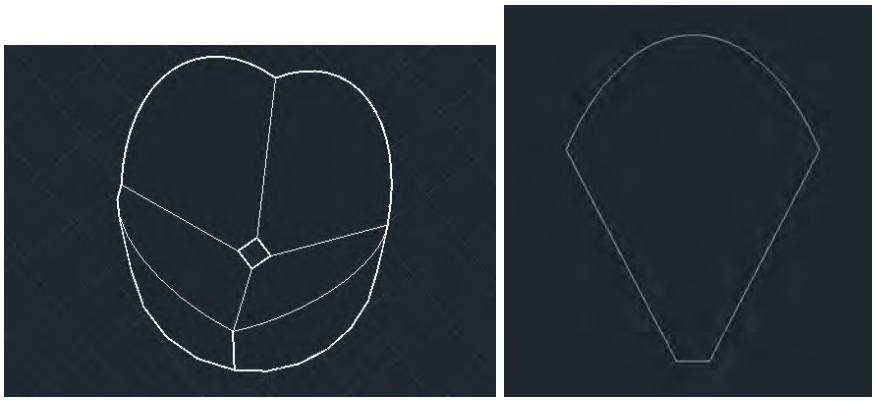


Figure 17: Funnel Design



Link 1: Link to video of initial petal drop testing
https://drive.google.com/open?id=1GaVHPYaoxgRzbUNnznDdjyV4wkpoFNVl.

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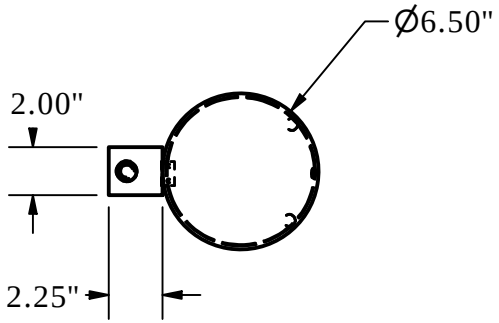

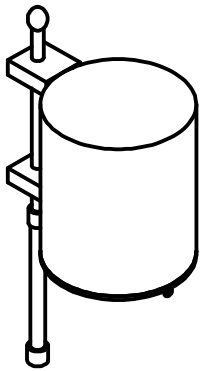

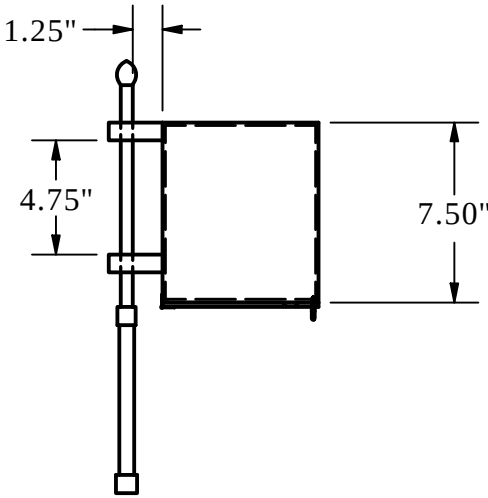

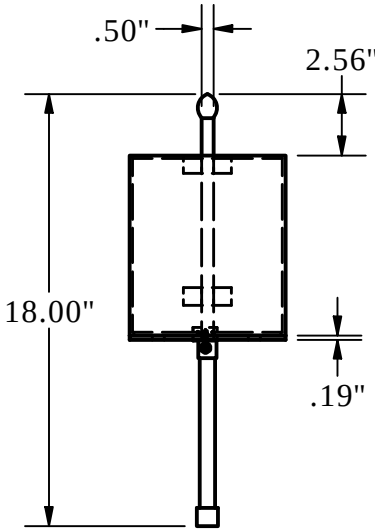

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Loading Device

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Scale:

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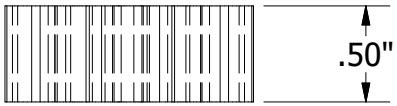

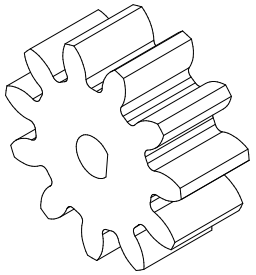

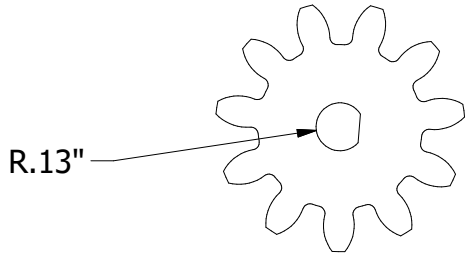

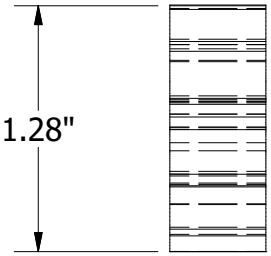

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Kovalenko

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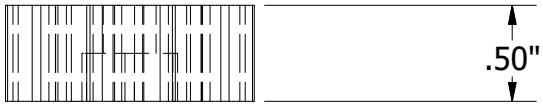

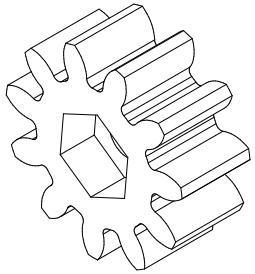

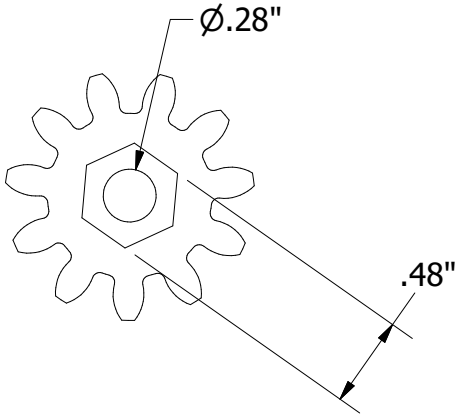

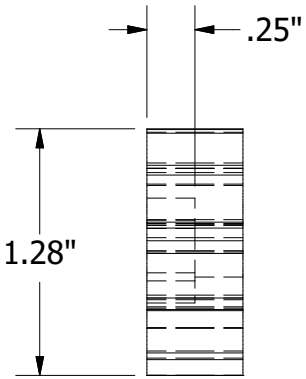

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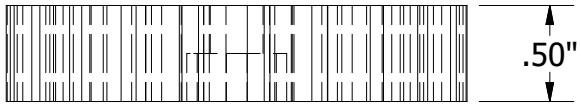

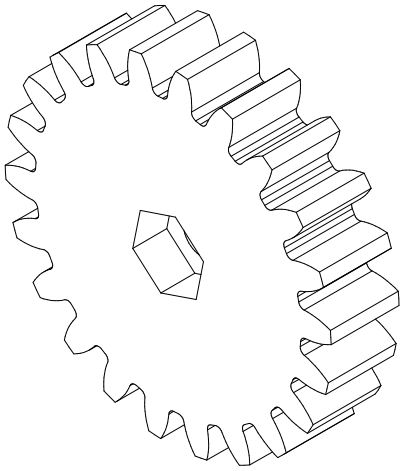

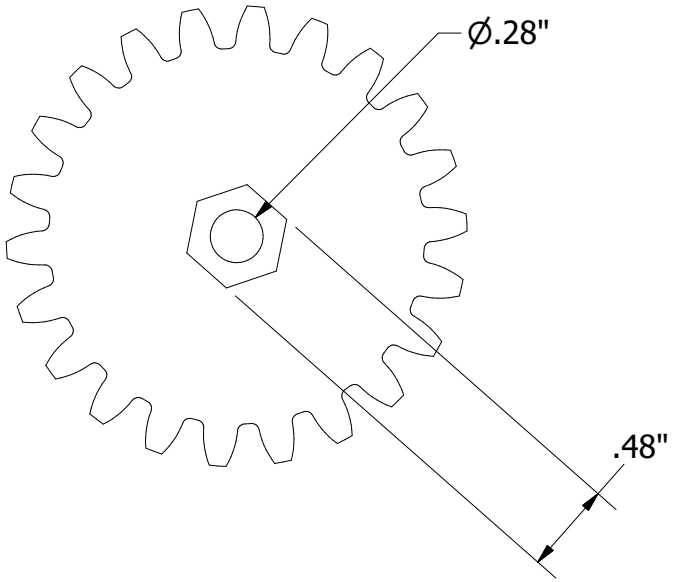

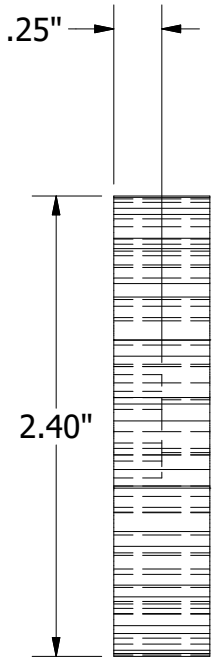

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Kovalenko

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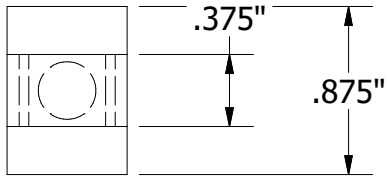

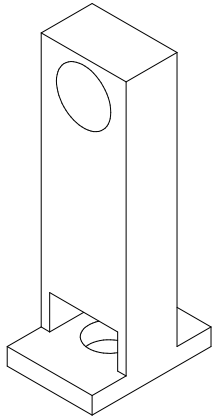

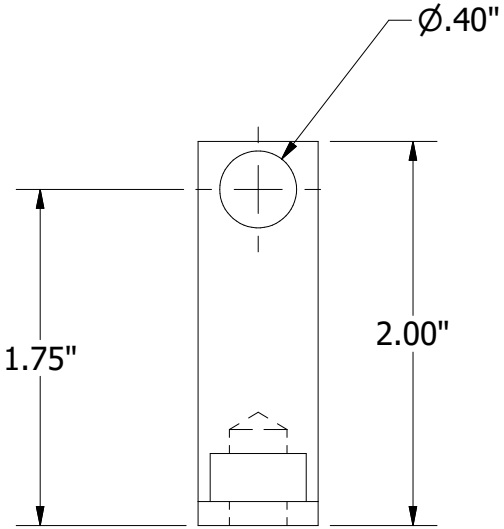

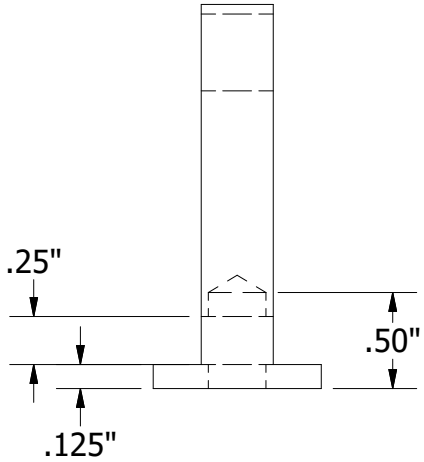

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Component:

Bushing Mounts

Drawn By:

Zachary Kovalenko

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4 / 4

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