MESQUITE BEAN HARVESTER

MIDTERM PRESENTATION

Senior Design 2 - Fall 2020

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Prepared for: Dr. Arturo Fuentes, Dr. Joanne Rampersad-Ammons, Dr. Noe Vargas, Mr. John Pemelton, and Mr. Gregory Potter

TEAM 3: AKA "TEAM 4-I"

FROM LEFT TO RIGHT: CARLOS GUZMAN, VICTORIA GARZA, STEPHANIE RAMOS, ALEXANDRA SALINAS

OUR TEAM LOGO

OUR PURPOSE

What if there was an easier way to harvest and collect mesquite beans to expedite the manufacturing process of Mesquite bean products?

OUTLINE

- Problem Identification
- Problem Formulation
- Conceptual Design
- Embodiment Design
- Future

PROBLEM IDENTIFICATION

INTRODUCTION

- Texas has a large amount of acreage on which the Honey Mesquite (*Prosopis glandulosa*) tree grows. The tree produces a bean which can be made into flour, jams and jellies to support a lucrative local agrobusiness.
- Currently all bean harvest is done with manual labor which severely restricts the quantity of beans that can be harvested and is hindering expansion of the industry.
- We seek a way to mechanize this process so that bean harvest can be expanded.
- The complex biology of the mesquite tree poses as a unique challenge.

PROBLEM FORMULATION

BACKGROUND RESEARCH

- **History of Mesquite**
  - Days of the Indigenous
  - Nutritional Value
- **Biology and Properties of Honey Mesquite**
  - Complex Biology and Geometry
  - Mechanical Properties
    - Modulus of Elasticity
    - Poisson's Ratio
- **Alternative Harvesting Methods**

COMPETITIVE PRODUCTS

- Manual Labor
- Olive Picker
- Tree Shakers


Cappadona Boys Picking Mesquite Beans

USER RESEARCH

- Main Source of Research came from the Cappadonna Ranch.
  - Field Research conducted for measurements of beans, branch diameters, canopy radius, etc.
  - Interviews pertaining to pains and gains of their business, what has been done, and so on.
  - Task Analysis through interviews and visitations of the company to grasp the problem at hand.
  - Online research of methods of harvesting fruits and nuts through vibrations proved to be incredibly helpful to understand our design.

DESIGN SPECIFICATIONS: EXCITATION

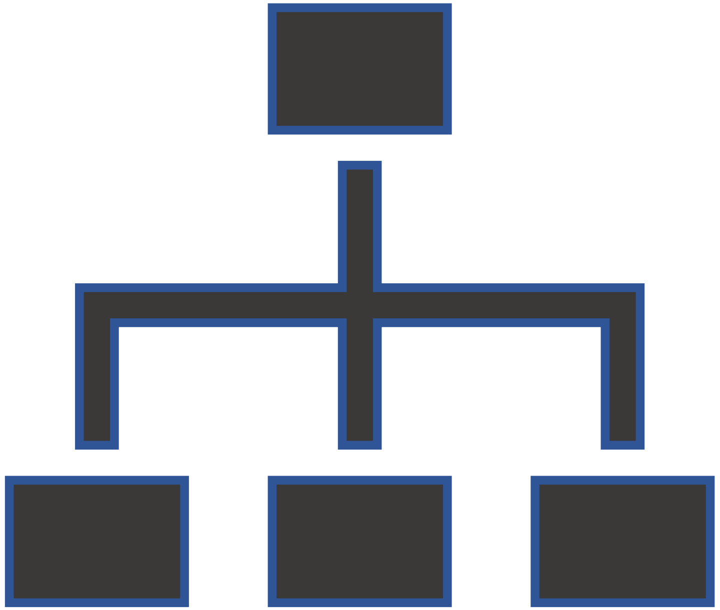
Mesquite Beans

- Arm Extension must reach 11 feet maximum, based on the height of the canopy of the tree.
- Localized Excitation
  - Sacrifice time over losing product
  - Global Excitation would waste more energy for the least amount of production.
  - Randomness of Bean Ripening calls for localized excitation
- Branch interface to cater to branch diameters of 5-10 inches

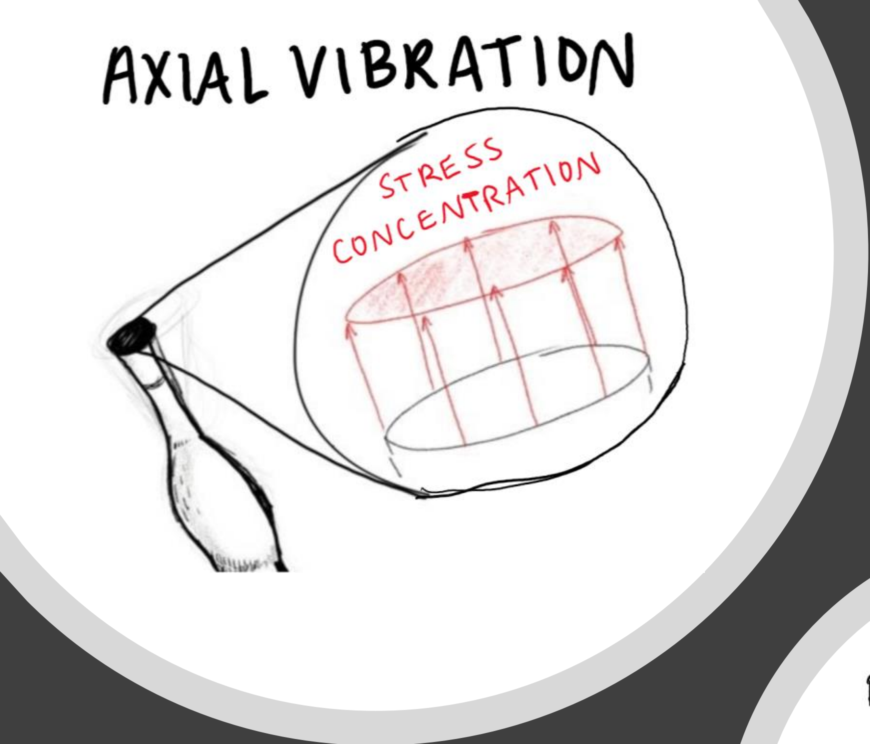
DESIGN SPECIFICATIONS: COLLECTION

- Localized Collection
  - For Localized Excitation
  - Saving Money
  - Better Maneuverability
- Material
  - Durable enough to withstand the sharp mesquite beans on impact.
  - Material testing techniques will be used (i.e. drop tower test, tensile testing of fabrics, ASTM Standards, etc.)
- Coverage
  - 5-10 ft to outer edge of canopy
  - Adjustable height because of randomness of canopy heights

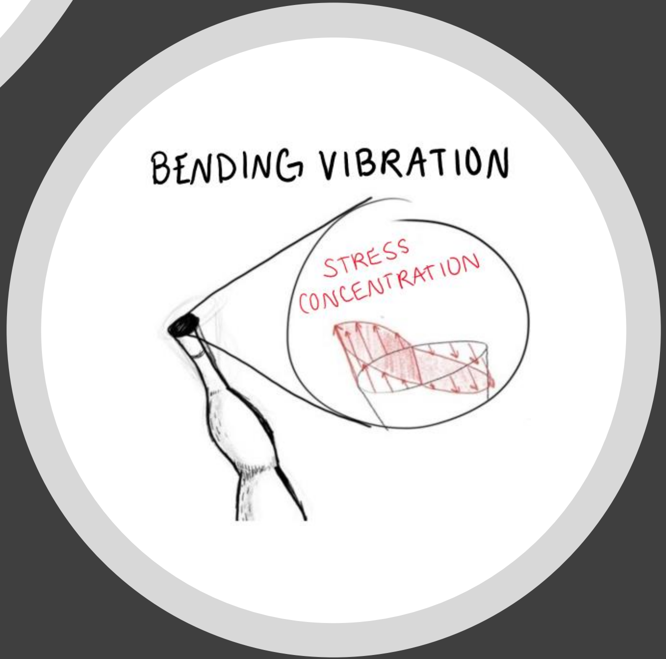
Honey Mesquite Tree

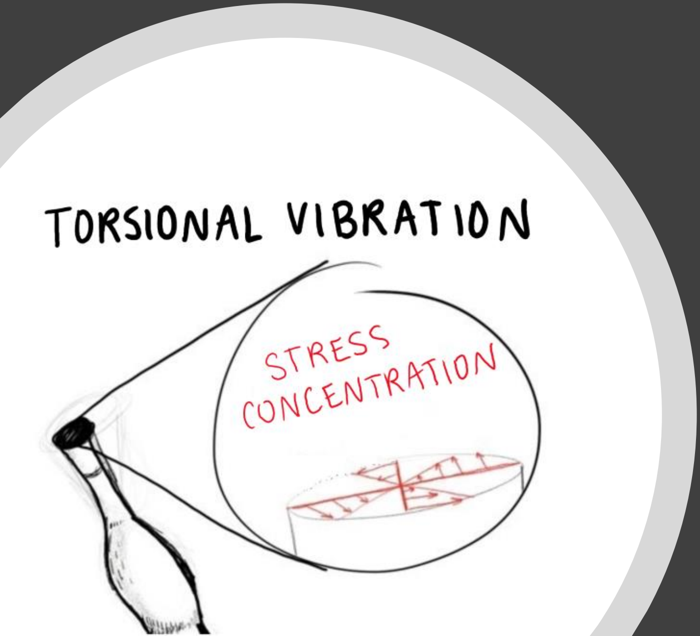


CONCEPTUAL DESIGN



TYPES OF VIBRATION AND STRESS CONCENTRATIONS

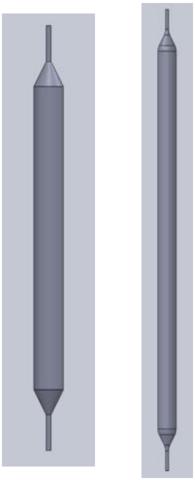




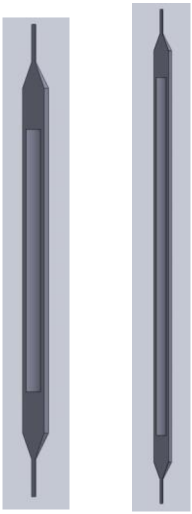
- Axial
  - A kind of longitudinal shafting vibration
- Bending
  - Vibration due to an external load applied perpendicularly to a longitudinal axis of the element.
- Torsional
  - Is an angular vibration of an object—commonly a shaft along its axis of rotation.

ANALYSIS OF MESQUITE BEANS

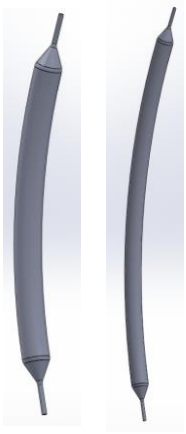
- For the Finite Element Analysis approach, Computer Aided Design (CAD) models will be created.
- A Frequency study will be completed for each model. The different modes of vibration and the natural frequencies of the beans with stems will be determined.
- A vibrational analysis was completed for a sanity check.



LEFT TO RIGHT: Short Bean, Long Bean. Solid, Straight.



LEFT TO RIGHT: Short Bean, Long Bean. Hollow Straight.

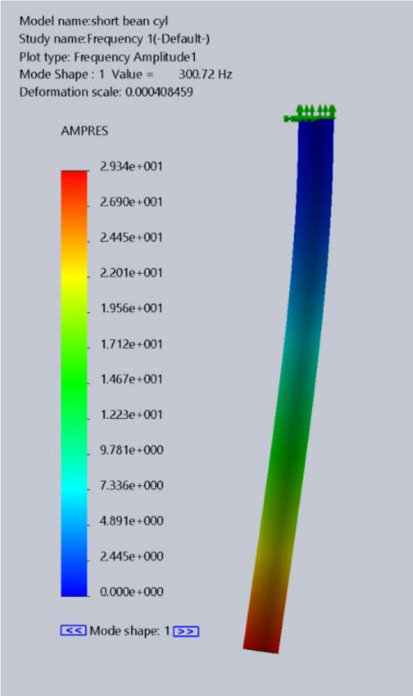


LEFT TO RIGHT: Short Bean, Long Bean. Solid, Curved.

LEFT TO RIGHT: Short Bean, Long Bean. Hollow, Curved.

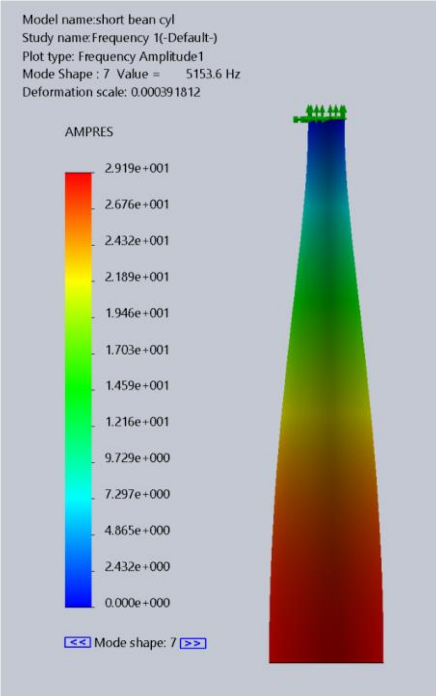
ANALYSIS OF MESQUITE BEANS

BENDING



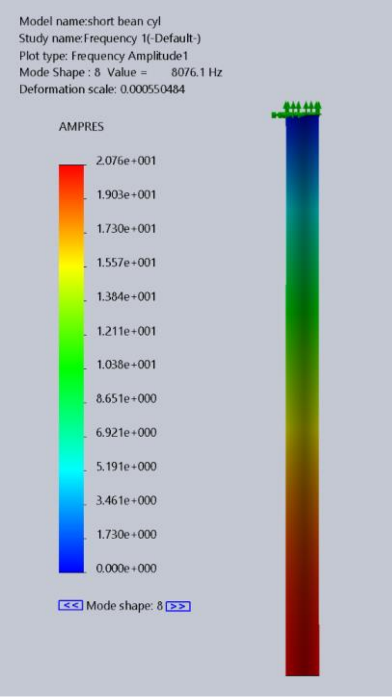
	Theoretical	Solidworks
ωn (rad/s)	1892.2441	1889.4795
f (Hz)	**301.16**	**300.72**
Error (%)	0.146	

TORSIONAL



	Theoretical	Solidworks
ωn (rad/s)	32605.789	32381.024
f (Hz)	**5189.37**	**5153.6**
Error (%)	0.689	

AXIAL



	Theoretical	Solidworks
ωn (rad/s)	50722.7	50743.633
f (Hz)	**8072.77**	**8076.1**
Error (%)	0.041	

ANALYSIS OF MESQUITE BEANS

LOWEST

HIGHEST

Overall Frequency Range		
Bending		
	Lower	Upper
ωn (rad/s)	50.5708	151.079
f (Hz)	**8.0486**	**24.045**
Torsional		
	Lower	Upper
ωn (rad/s)	679.966	2492.85
f (Hz)	**108.22**	**396.75**
Axial		
	Lower	Upper
ωn (rad/s)	8279.35	23256.6
f (Hz)	**1317.7**	**3701.4**

Frequency Ranges of the Different Methods of Vibration

- With the varying mesquite bean geometries and their respective natural frequencies, the smallest and largest frequencies for each method of vibration were compared to one another.
- Axial and Torsional Vibration are not suitable, given that their ranges fall closer to acoustic vibration.

INTERPRETTING OUR ANALYSIS

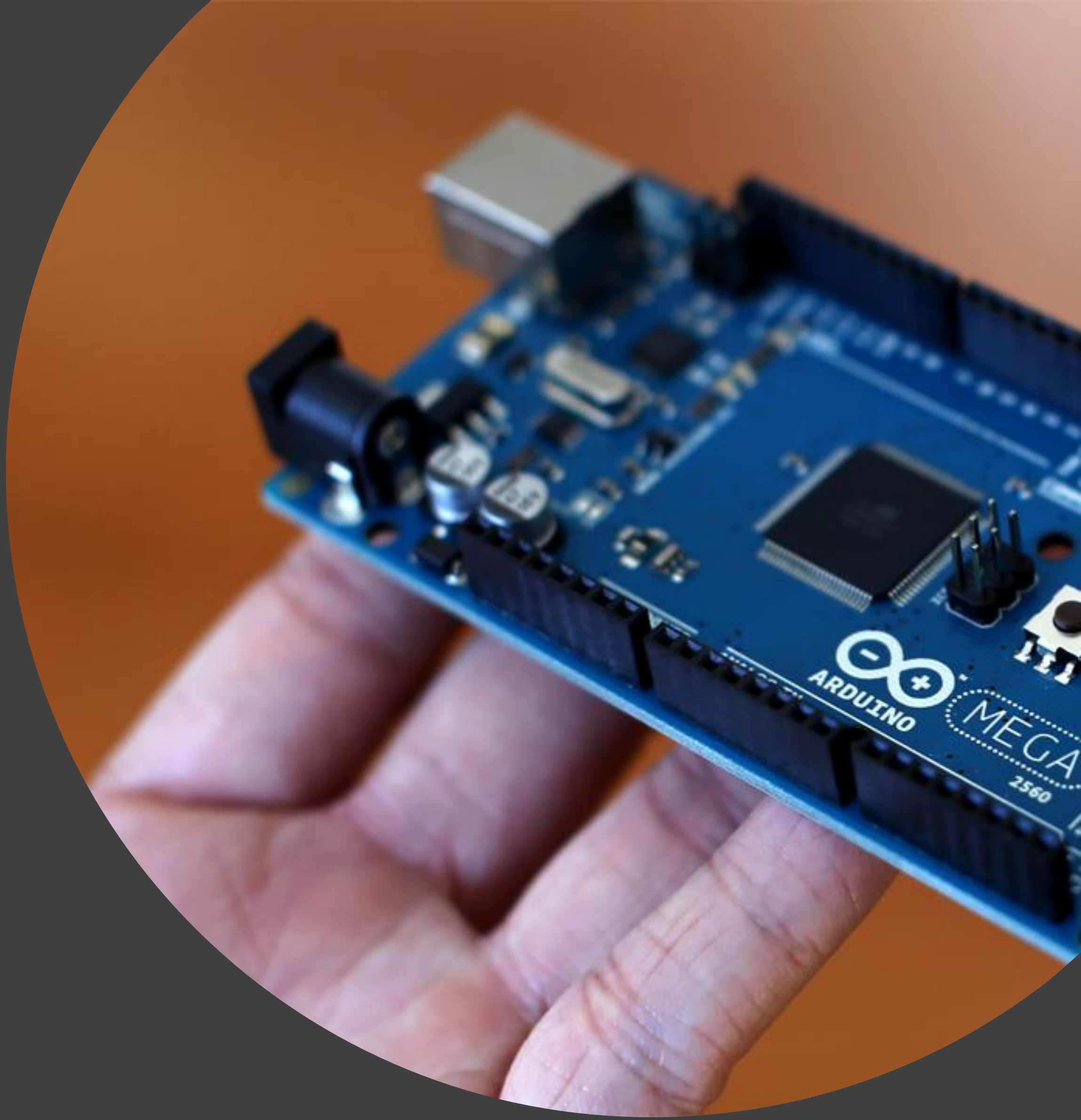
- Bending Vibration is the prospective method of vibration on its own.
- The mesquite bean will reach resonance once its natural frequency is met and applied for a prolonged amount of time.
- Curvature of bean could facilitate both bending and torsional vibration.

Bending		
	LOWER	UPPER
ωn (rad/s)	50.5708	151.079
f (Hz)	8.0486	24.045
RPM	482.916	1442.7

Prospective Vibration and Its Corresponding Motor Speed

EXCITATION BREAKDOWN

- ***Branch Interface***
  - Interface requires connection between machine and branch to allow for constant vibration.
- ***Method of Vibration***
  - Different mechanisms have different variables that are considered. The method that is applied will also affect the target vibration modes.
- ***Control***
  - Methods of controlling vibration is essential to both holding the vibration frequency and to connect the machine together.



COLLECTION BREAKDOWN

- ***Guiding Beans***
  - Guiding the beans requires that there is a location for beans to fall and allow for the guidance of the beans to the next step of the process.
- ***Storage***
  - Storage of the beans is the final step of the system. With the guidance of the bean to the storage selection, the beans reach their destination where the user can use the beans for the next step of their manufacturing process.

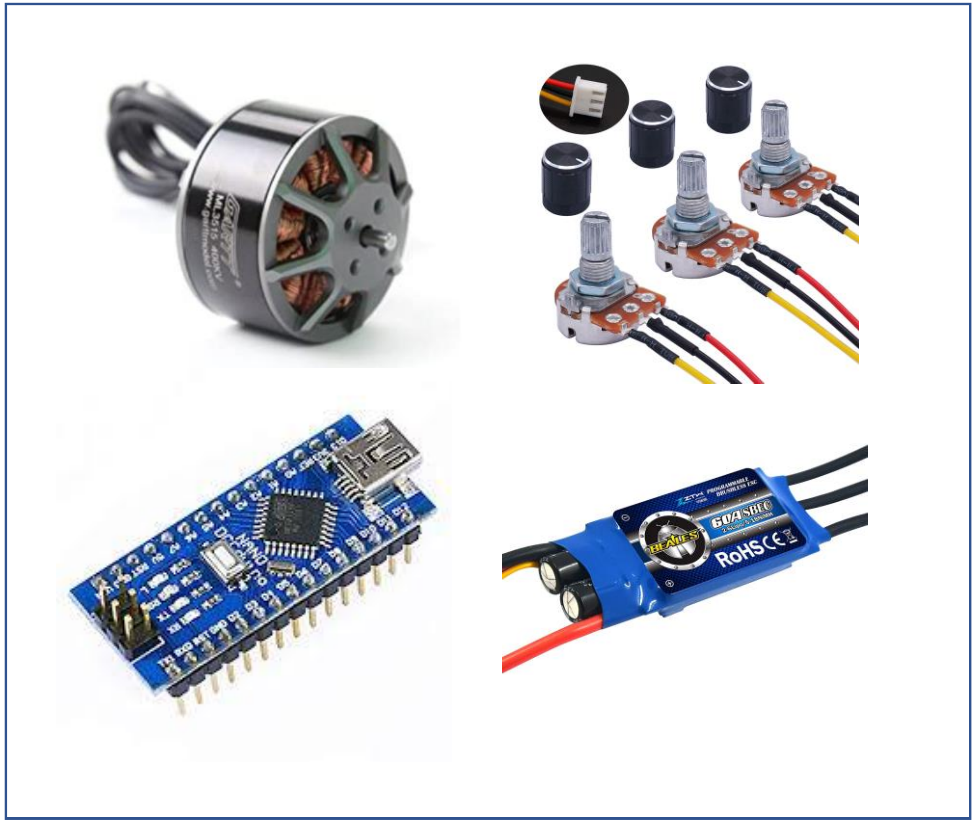
EMBODIMENT DESIGN

EXCITATION MATERIALS

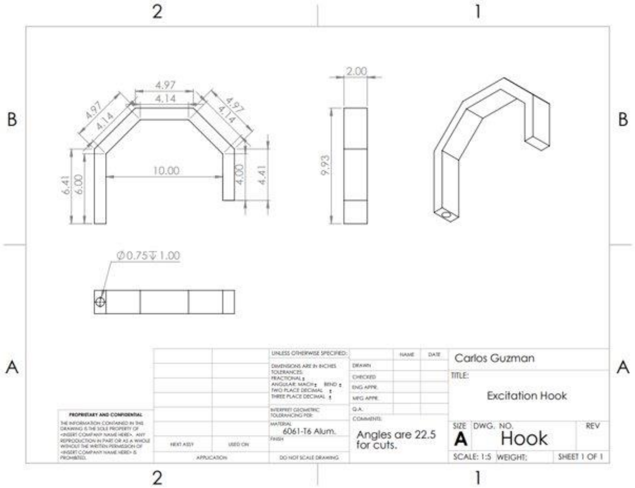
Power Source/Charging

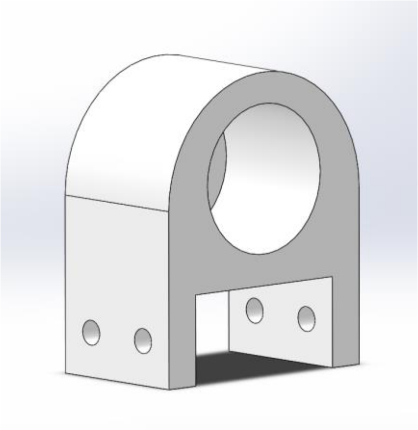
Extension/Reach

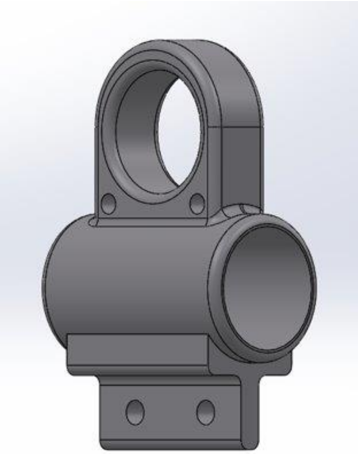
Excitation Modules

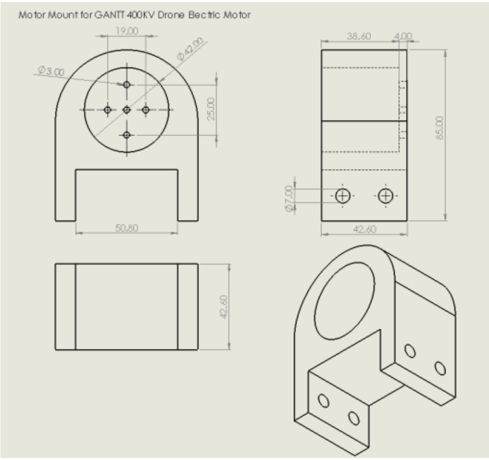


EXCITATION SOLID MODEL







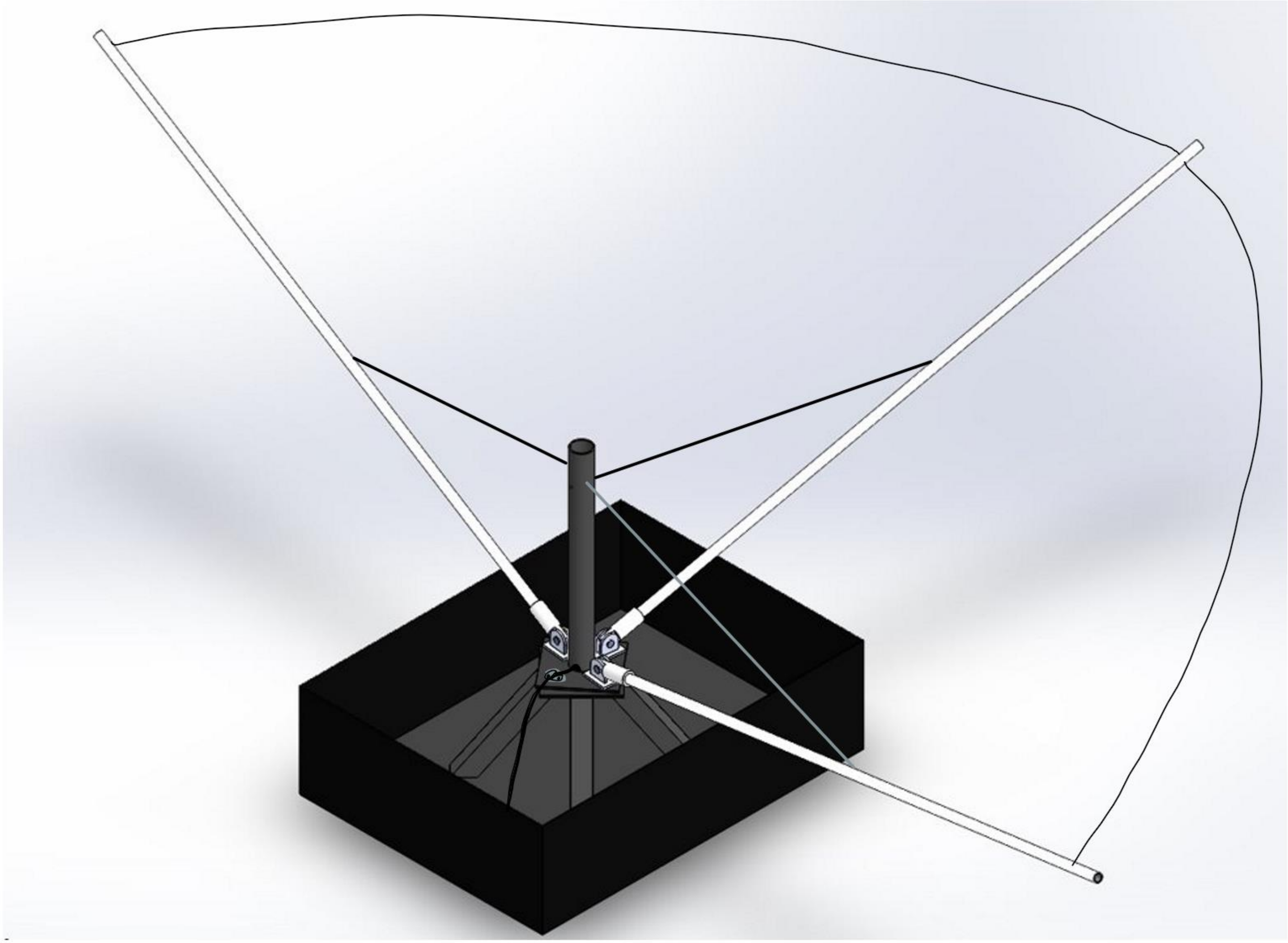


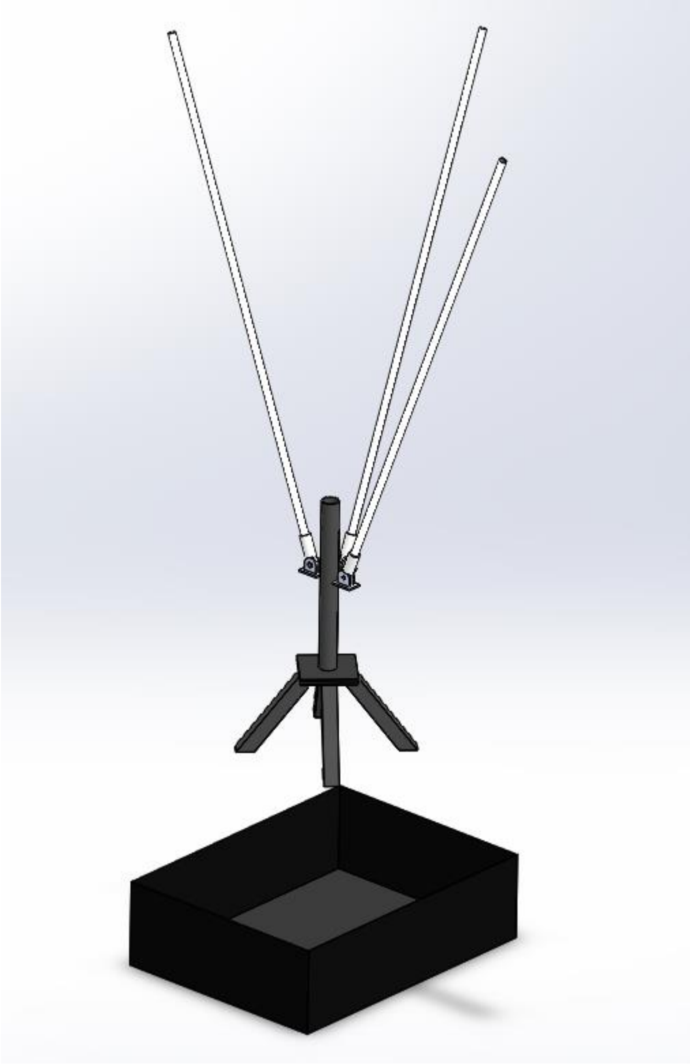
COLLECTION MATERIALS

Bean Guidance

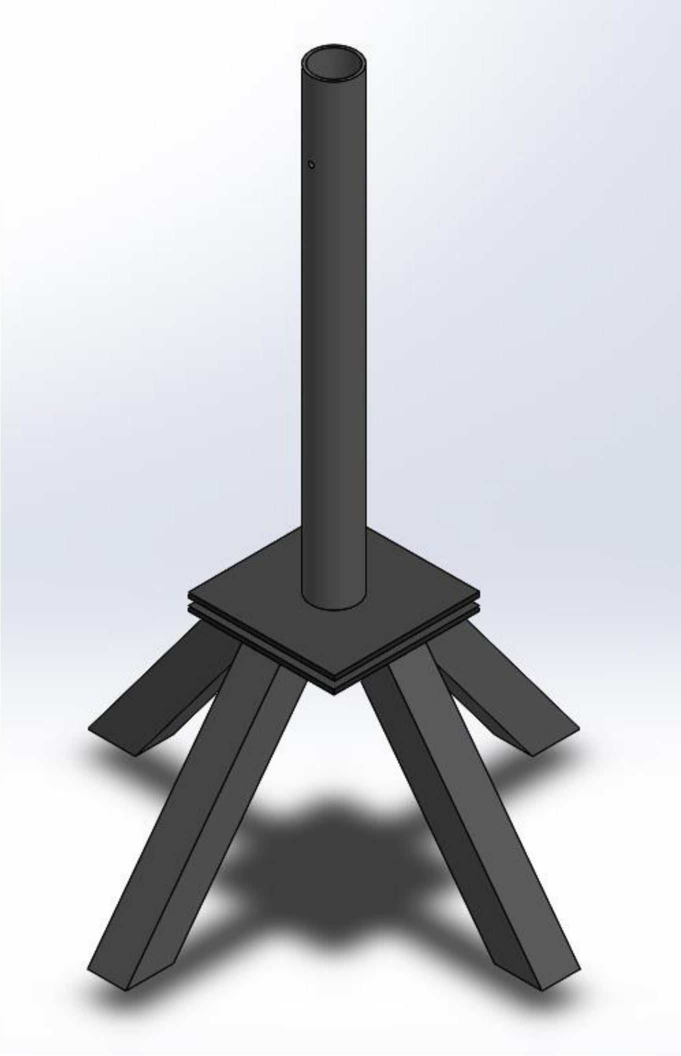
Bean Storage

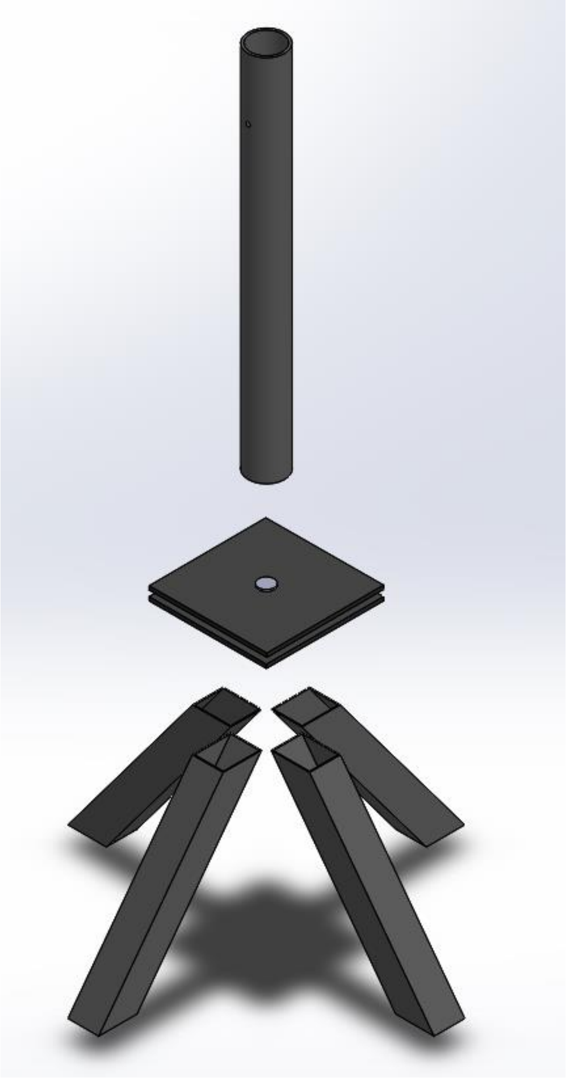
COLLECTION SOLID MODEL





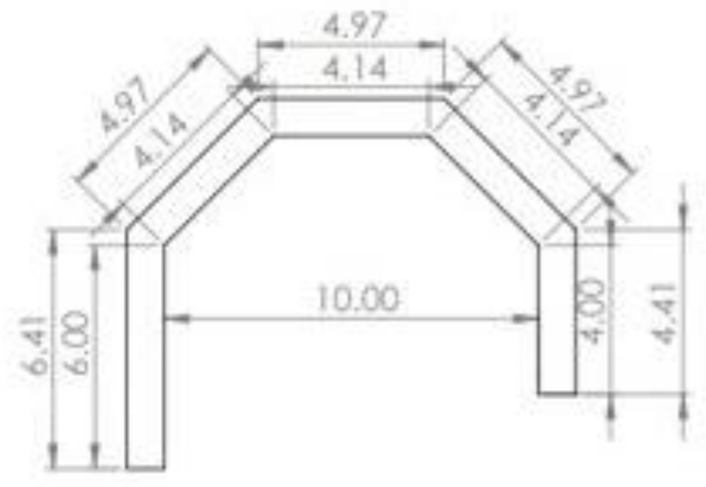
COLLECTION SOLID MODEL

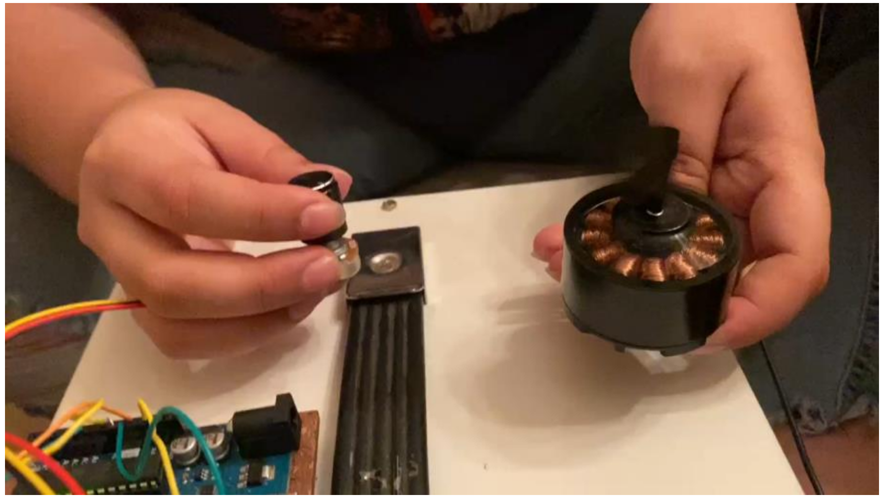


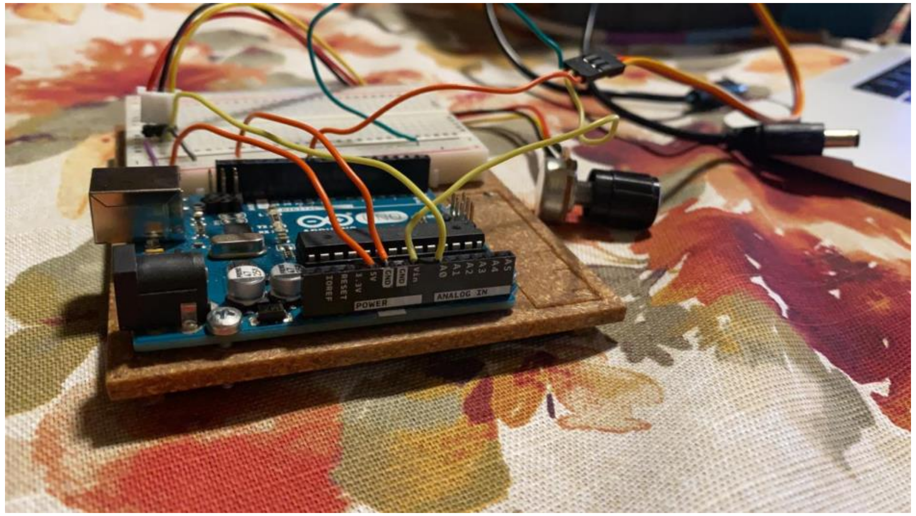


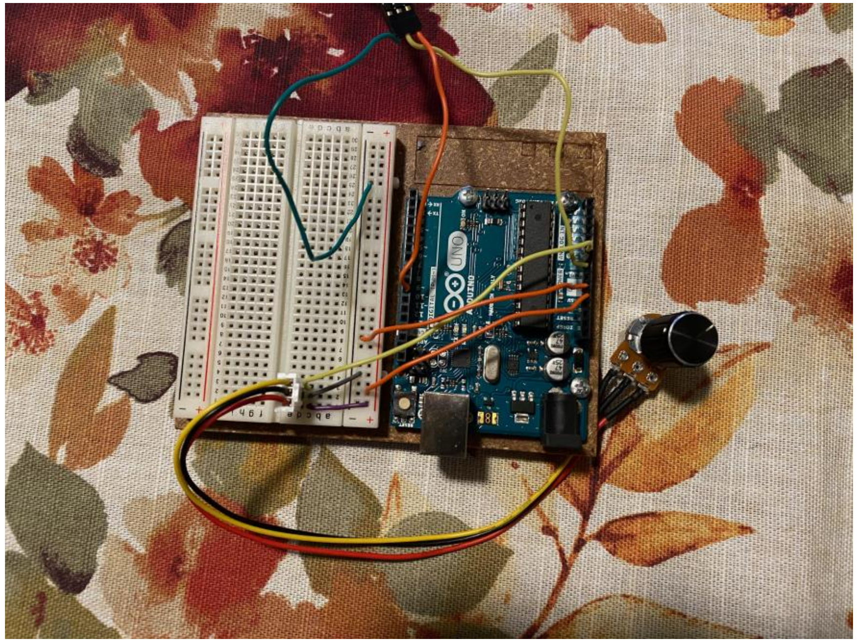
MANUFACTURING OF EXCITATION HOOK

- A 1" x 1.5" aluminum bar had been manufactured and welded to create our first hook prototype.
- Milling still needs to be completed for the extension pole insert.
- Instead of creating the necessary threading (which is not available to us), we have decided to use a pin to secure it into place.



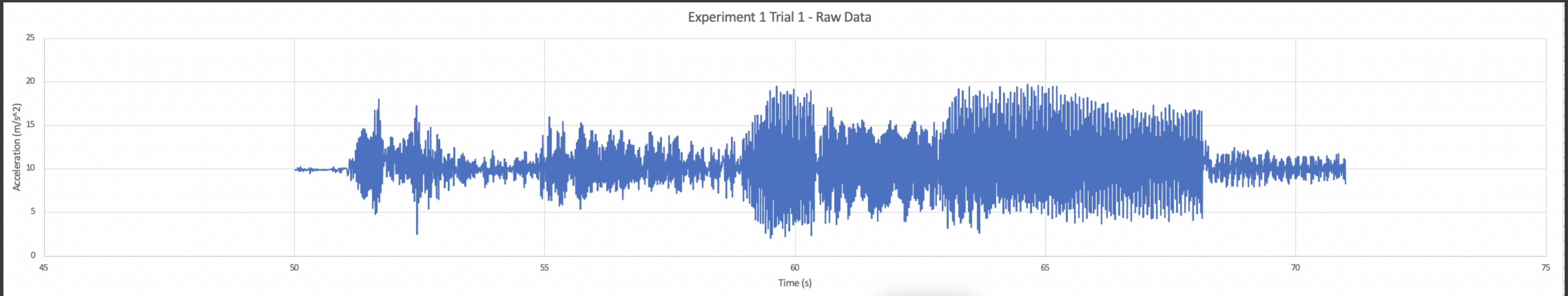






ASSEMBLING OUR CIRCUIT

EXPERIMENT #1



OBTAINING DATA FOR EXPERIMENT #1

Oct. 13, 2020
Vibrational Experimentation

- Mounting the motor on the branch, we began experiencing motor issues due to previous wear on wires.
- Testing showed that the motor was damaged, will need to be replaced or repaired.

EXPERIMENT #2

Resolved Challenges from Internal Review

Welding

- Collaborating with Mr. Sanchez

Season of Harvest

- Developed a way to put the bean back onto tree to test

Missing Materials

- Thanks to Dr. Jo and the Ag-Grant, we were able to obtain vital materials to complete both projects.

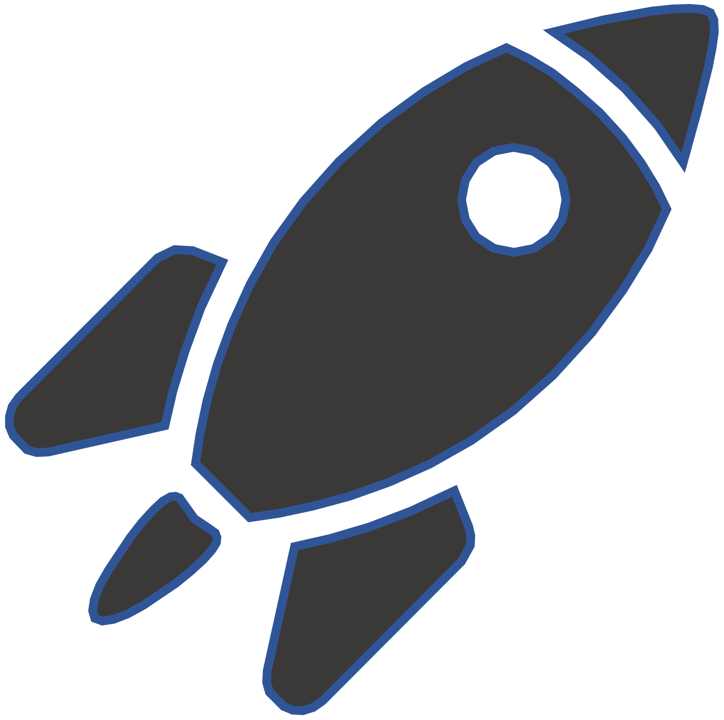
Current Challenges

Motor

- No longer works
- Motor does not facilitate the correct level of vibration

Machine Shop

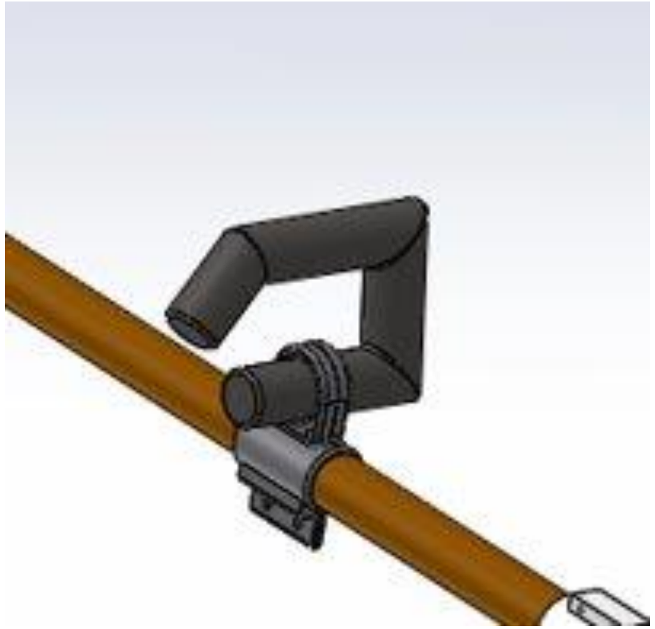
- Collaboration with Lab TAs and supervisor
- Hammer project cut short due to COVID-19



FUTURE

Excitation

- Switch over to an Arduino Nano
- Use approx. 12' long wires that will extend with the extension arm
- Using 3D printer to make side handle
- Obtain a low-weight accelerometer to maintain a minimally invasive testing procedure.



-Excitation-
Future Testing

Distance of system from the bean

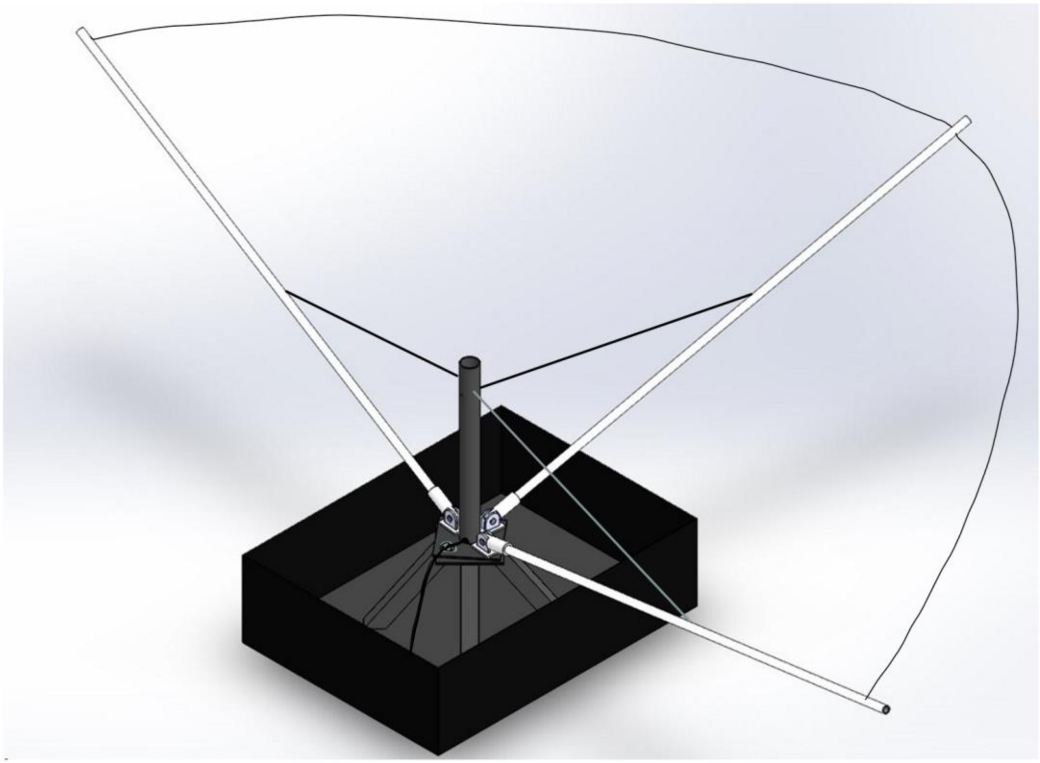
Offset Mass Size

Resonant Frequency based on bean size.

Position of motor on
hook for minimal vibration dissipation

Collection

- Building tarp assembly
- Welding the steel framing onto steel cart bed.
- Mount PVC piping onto the swivel sheet.
- Simulate retraction of tarp arms.



-Collection- Future Testing

Determine maximum stresses through the Finite Element Analysis Method

Fine tune tarp retraction

Determine the force of impact of the beans on the tarp and determine the smallest tarp angle that will facilitate bean guidance.

HIGHLIGHTING PIVOTAL MOMENTS

The ability to excite the mesquite branches is progress for our project. Through this, we can focus on making a bean fall using the exact same testing methods.

Thanks to Dr. Jo and the Ag-Grant, we were able to obtain vital materials to complete both projects.

REFLECTION

- Through our failures we have redirected ideas and reinvented designs. They have revealed limitations and inspired resolutions.
- Every single day was a constant learning experience about direction and where we needed to go.

CONCLUSIONS

- We still have plenty of work to do. We are looking forward to continuing our hard work and remaining optimistic and positive, regardless of the challenges faced.
- Final prototypes for both projects are within view and our team is ready to continue moving forward.

ACKNOWLEDGMENTS

Dr. Fuentes

Dr. Rampersad-Ammons

Dr. Vargas

Mr. Pemelton

Mr. Potter

Mr. Sanchez

Cappadona Family

Q&A

APPENDIX

LAYOUT 1: SDI SEMESTER TIMELINE

"Lowes" Prototype for Collection and CAD model for Excitation should be completed by the end of May.

More research is being done on offset mass motors.

Developing a method of testing by utilizing 3D Printing techniques to de done by end of May.

Discussing prospective materials for both collection and excitation designs by early June.

SUMMER PLANS – LAYOUT 2 TIMELINE

- Continue to make progress on Embodiment Design through layering our design to become more complex.
- Manufacturing parts and assembling a prototype.

- Utilize developed testing method created in Layout 1
- Create mesquite branch and bean with 3D printer to simulate the bean drop with excitation

DAYS OF THE INDIGENOUS

For Native Americans of the desert regions, mesquite was not only relied on as a dietary staple, but as the most important economic plant of their culture. The Papago, Pima, Yuman, Cocopa, Mohave and Cahuilla peoples of Arizona and California utilized all parts of the mesquite:

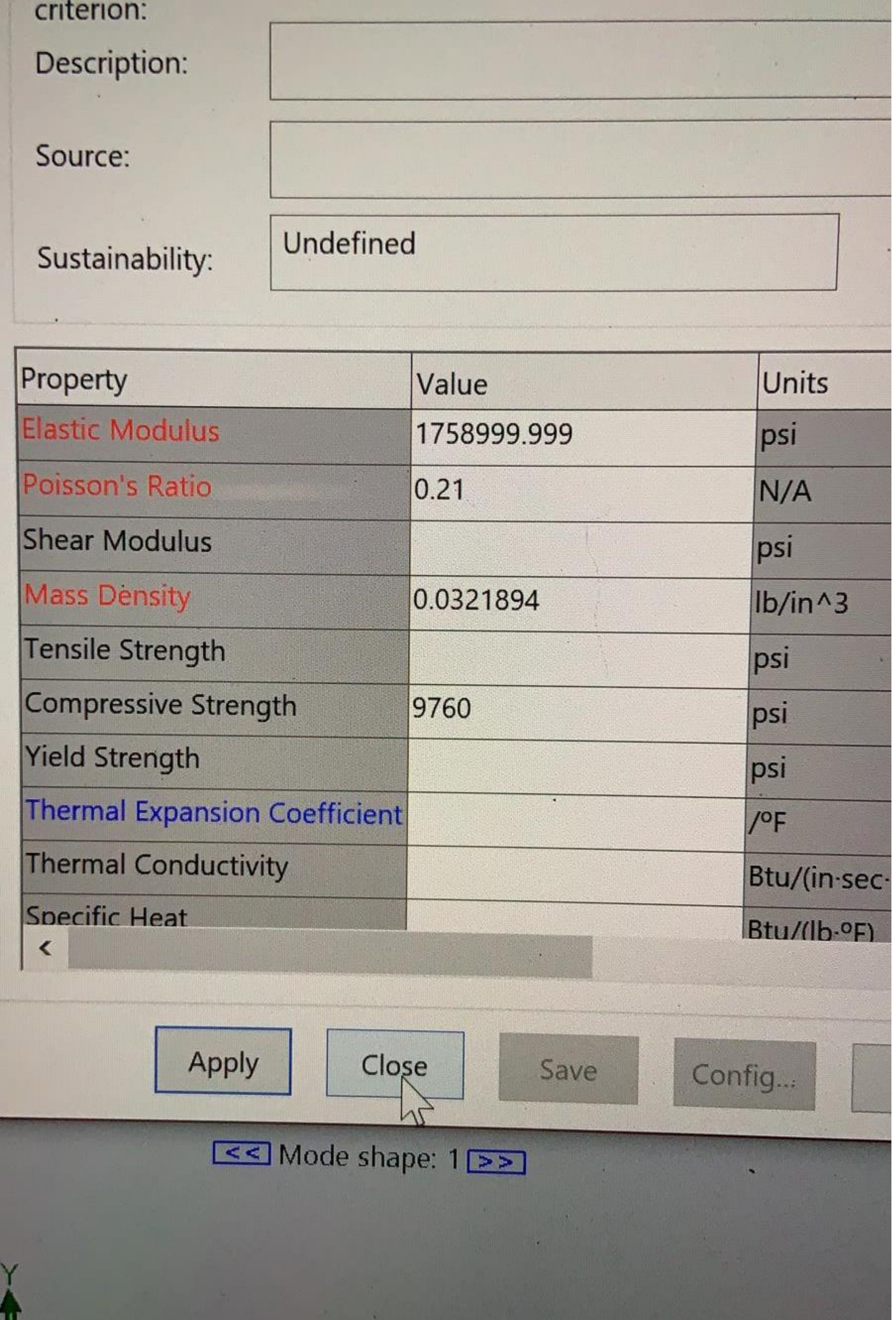
- **Bark** - basketry, pottery, fabrics and medicine
- **Trunk & Branches** - firewood, in the manufacture of bows, arrows, mortars and furniture
- **Thorns** - awls and for tattooing
- **Leaves** - making tea, used medicinally as an eyewash and for head and stomach aches
- **Sap** - as a snack, glue and dye.

But it was the mesquite pod, with its nutritious, bittersweet pulp, that provided the greatest benefit to indigenous desert peoples. They collected pods each fall, often eating many of them green from the trees. The rest they dried in the sun and stored in large baskets for future use.

https://www.desertusa.com/lil/Mesquite-Beans-recipes-lil.html

NUTRITIONAL VALUE

- The mesquite bean provides protein, carbohydrates, and calcium with four tablespoons of mesquite meal providing 70 calories (Niethammer, 1974); the ground pods can be used for foods ranging from crackers to breads to mousse (Niethammer, 1987), (Niethammer, 1974); the tree is a source of gum arabic-like gum (Facciola, 1998); dry pods ground and fermented made a food similar to old English mead (Curtin, 1997); cooked pods can produce molasses (Moore, 1989); catkins have been eaten as a starvation food (Rea, 1997); blossoms were picked by the Cahuilla, pit roasted, and then squeezed into balls ready for eating.
- https://www.desertharvesters.org/native-tree-information/more-about-mesquite/



PROPERTIES OF MESQUITE

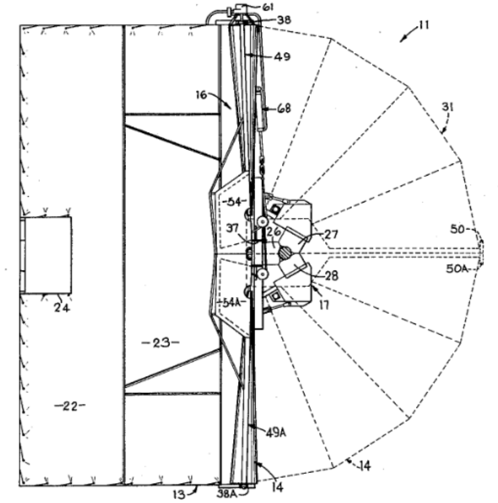
- Ediga Yathindra Goud, Dr. M. Nagaphani Sastry, K. Devaki Devi, Dr. H. Raghavendra Rao P.G. Student, Department of Mechanical Engineering, GPR Engineering College, Kurnool, AP, India Associate Professor of Mechanical Engineering, GPR Engineering Colle. " Mechanical Properties of Natural Composite Fibre *Prosopis juliflora*." *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 5, no. 9, 2016, doi:10.15680/ijirset.

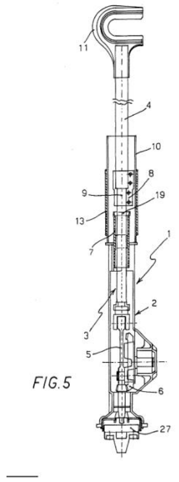
KEY QUESTIONS

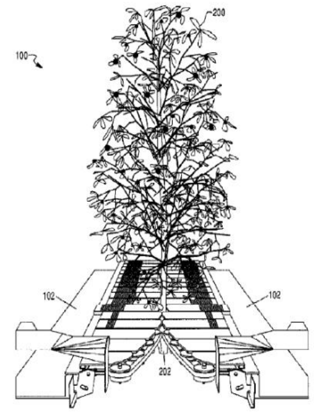
- Problem to Solve
- Product Opportunity GAP
- Current Solutions
- Value Proposition

Competitive Products

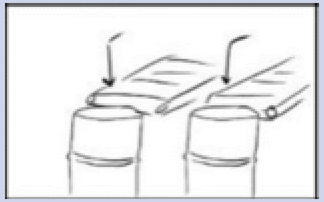
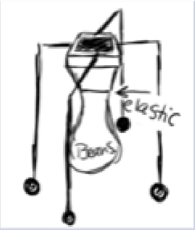
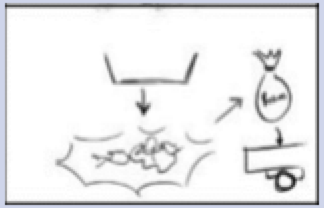
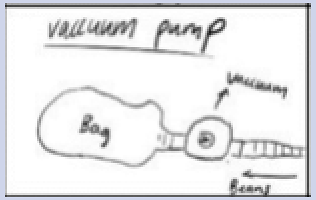
- Ferguson, Joseph M. *LIMB SHAKER*. 27 Aug. 1963.
- Friday, Philip L, and Hartford Township Van Buren County, Mich. *FRUIT AND NUT HARVESTING APPARATUS*. 26 May 1981.
- Griffini, Alberto, and Giorgio Buoli. *Tree Shaking Device for Collecting Fruits*. 22 Jan. 2003.
- Tyros, James C. *OLIVE PECKER WITH SPEED CONTROL AND SELECTED PICKER DEMENSIONS*. 16 Sept. 1986.
- YOUNG, TERRY, et al. *Mechanical Berry Harvester*. 11 Sept. 2014.

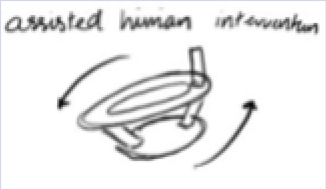
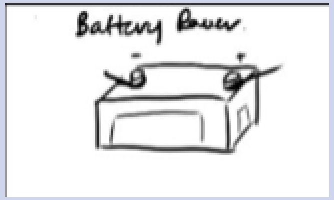


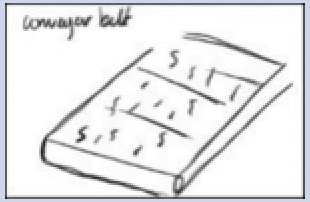
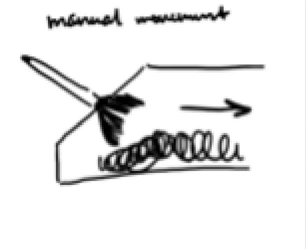
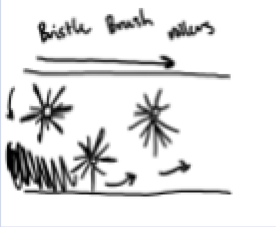
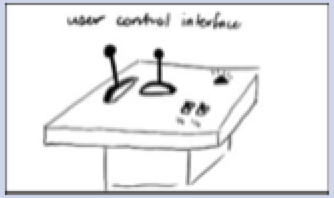
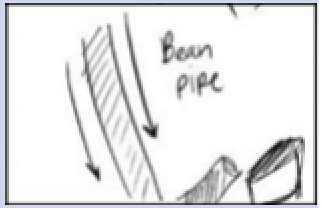


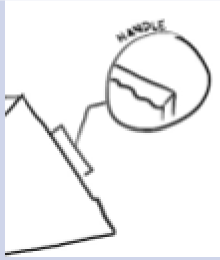
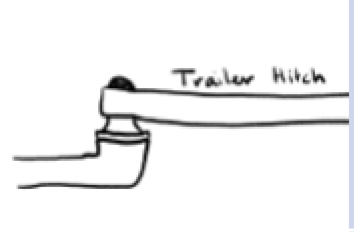


COLLECTION SUB FUNCTIONS

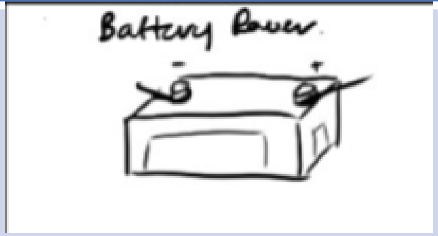
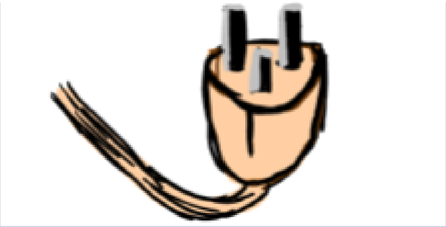
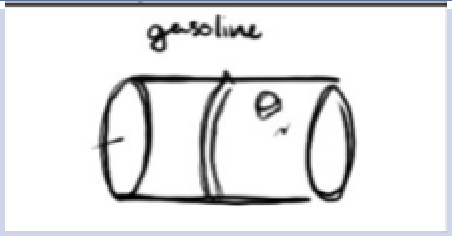
Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4	Solution 5
Storage					
Ease Of Use	Easily attached to the end of the vibration brush, integration between excitation and collection.	A bag can be attached using an elastic band, can be easily attached and removed once filled.	Can be constantly changed out. Probably more labor intensive with lifting.	Labor-intensive, the bag would have to be large enough to catch almost all of the beans, gathering the beans will not minimize the material being used.	Easy to use. Would run along the trees to simulate wind. However, the beans would probably fly in different ways, causing them to be much harder to collect.
Cost	The hopper attachment may be created using a polymer of some sort that can handle the sharp points. Price varies on material.	Bag Material may be more costly versus burlap, since we need to account for the sharp point on bean pods.	Typical Trash cans made from a polymer. Could be the barrels that the Cappadona's have already. Little to No cost.	Could become very expensive because of the constant changing of the plastic bag.	Not too expensive, about the same cost as a high-grade vacuum. Shop-Vac, etc.
Maneuverability	May have issues maneuvering the bin with the attachment. The offset mass may be too overbearing for the user.	Bag is dethatched and carried manually by user. Transported to a vehicle for sorting process.	Could become very heavy with all the beans collected. Could be difficult to lift.	This would probably not be put all the way around the tree, only specific sections of the tree. The material would have to withstand various environments because it will be laid on the ground of the ranch.	Reduces the need for being underneath the tree. A series of piping and suction through a displacement. The beans could get stuck in the piping, as well as small animals, leaves, etc.
Safety	Removes the user's physical interaction with the bean to drop into a hopper. User is not harmed by the process.	Lifting the heavy bags could cause injury if done incorrectly, however the beans will be transported efficiently.	Safety would probably be maximized. However, lifting the heavy barrels could cause injury if done incorrectly.	The workers would have to go underneath the tree and risk their safety because of the thorns and overgrowth under the trees.	Safety would probably be maximized. However, it runs the risk of having 'backups'.
Conclusion	The hopper may be top-heavy, but the process can be integrated in another fashion to minimize cost and maximize safety.	Reloadable bags minimized reload time and leads to an easier method of transporting beans to the sifting process versus collections into a barrel.	The barrels would minimize the cost of the project. However, this will not make the task of transporting beans easier.	This process is labor-intensive and is cost-heavy.	Too much uncertainty with collecting the beans and the overall function of the machine could be compromised.

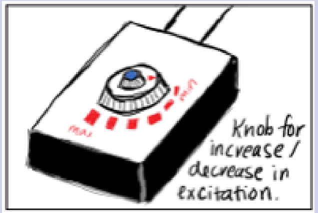
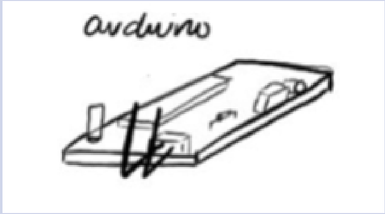
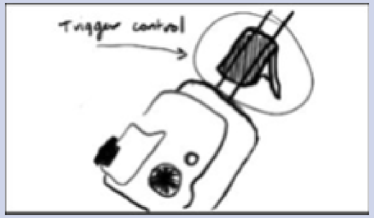
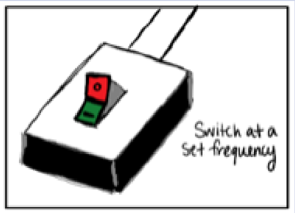
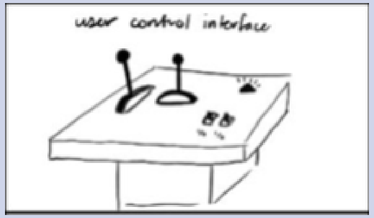
Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4
Power				
Ease Of Use	Manual labor, more labor-intensive than the other solutions.	Easier to integrate into the project. Ability to recharge and apply voltages.	Coding is necessary for production. Would probably need a smaller battery.	Would have to be highly integrated with the excitation machine. Would take a lot of energy.
Cost	Little to no cost unless it is made in a way that it can be used much easily.	Cost of a car battery.	$80+	High Cost with material and gasoline.
Maneuverability	A series of gears, cranks, pulleys, etc.	Easier to move around, smaller in size.	N/A	Heavy Machinery. Cannot be handheld.
Safety	Safe, unless used incorrectly.	Possible safety hazards when in contact with different weather conditions.	Possible safety hazards when in contact with different weather conditions.	Could be dangerous. Flammability. Not to be used in many weather conditions.
Conclusion	Safe for use and completes the job, but it is more labor intensive.	Would have to be integrated with other aspects of the project for implementation.	Would have to be integrated with other aspects of the project for implementation.	A high-cost machine, that is not easy to maneuver.

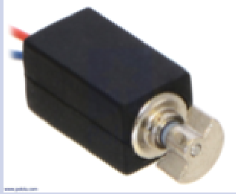
Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4	Solution 5
Method of Movement/Control of Beans					
Ease Of Use	Would be a retractable conveyor belt that can be mechanically retracted and pulled manually.	User does not physically touch the beans, but may be hard to stick the broom/brush in.	Removes the user from the equation, mechanically moves the beans through shafts and brushes. All done at the flip of a switch.	Would require training for the workers.	Runs the risk of getting the beans stuck within the piping. Prone to having the beans 'backup'.
Cost	Timely to manufacture, expensive due to motors, controls, and materials.	Extremely Inexpensive.	Expensive to make, requires motors and Arduino to coordinate the shaft.	Expensive	Inexpensive.
Complexity	Requires K&D, knowledge of Arduino related electronics, motors, machine elements, and geometry to get the right shape to work.	Not complex by any means, just requires a user with a broom.	Requires K&D, knowledge of Arduino related electronics, and machine elements to control shaft rotation.	Complex in terms of electronics.	Not Complex. The material would have to withstand the sharp points of the mesquite beans.
Safety	Tarp runs along the ground but serves as a barrier to the beans. Does not introduce contaminants to the beans.	Removes physical contact with beans (hand touching) but may introduce contaminants into the beans.	User isn't exposed to sharp bean pods, however, would be incredibly unsafe for user to stick body parts in. Also small critters need to be considered.	Safe from poor weather conditions but would not be very mobile.	Removes the need to go under the tree to collect, removes thorn hazard.
Conclusion	Could be a sufficient solution considering that the time and effort is put in to ensure optimal canopy coverage on the ground.	Extremely inexpensive, but may degrade the food, further research will be needed, but we'd like to avoid it if possible.	Could be used in ideal conditions, but may be difficult to manufacture, maintain, and may be costly.	Complex and Immobile. Would be expensive and require more attention.	Although inexpensive and safe, it would have one integrated with another aspect of the project to work. The function of the pipe could be compromised.

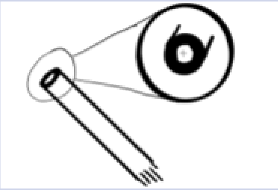
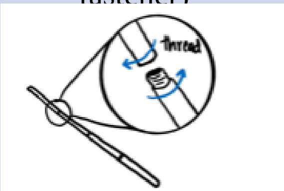
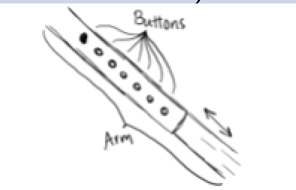
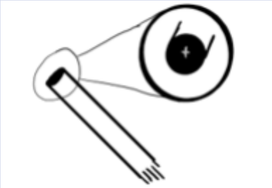
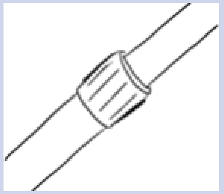
Sub Function	Solution 1	Solution 2	Solution 3
Transportation			
Ease Of Use	Tires need to be big enough for the ranch terrain to not break	Can be grabbed to guild the machine to a new localized spot of the tree	Easy to attach and move from tree to tree
Cost	Depending on the size of wheels needed can get pricy	Easy to find at Lowes	can be relatively expensive
Complexity	Helps moves over the ranch	will help move from location to location	helps move from tree to tree
Safety	if there is a flat can easily be replaced	increases safety by having a hand hold to move the machine	can easily be removed and attached
Conclusion	needed to keep up with the ranch terrain and helps with mobilization	needed to help facilitate movement around the tree	can be expensive but is a necessary investment to move along a large range of land

EXCITATION SUB FUNCTIONS

Sub Function	Solution 1	Solution 2	Solution 3
Power Supply			
Ease Of Use	rechargeable, long-lasting, and replaceable. good for both a single or multiple motor system	Need an external outlet and electrical source. Restrictions cause by cord length.	High Cost and high emission (not environmentally friendly)
Cost	car battery	will be connected to electronics so no additional cost	will change with the changing gas prices and might not be the most cost efficient
Maneuverability	heavy, however can be portable and able to carry back up battery.	low Maneuverability, cords can create limitations. Needs to be weatherproof with long extensions.	will need a tank
Safety	can be recharged but if dropped due to being heavy and can cause bodily harm	Electrical circuits are relatively safe. may short circuit or cause electrocution if not handled properly.	flammable
Conclusion	best for rotation of batteries to continue to work on trees while others charge	Inconvenient when working on a ranch and outlets are unaccusable. Relies on external battery source.	overall, not suitable for system due to high cost

Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4	Solution 5
Control					
Ease Of Use	needed for a range of frequencies	can be used as a brain to control direction of multiple motor or gears system.	throttle of intensity of the frequency	will not be a set frequency	a combination of other controls with a larger interface. More for a tractor attachment
Cost	Not expensive, $20+ for a knob. Casing would have to withstand heat, and wear and tear. Possibly a low-grade steel.	Arduino: already have 3 kits but if any other pieces need to be bought that will be at a higher cost	Trigger switches tend to be $20+	Not expensive, $20+ for a switch. Casing would have to withstand heat, and wear and tear. Possibly a low-grade steel.	Expensive to create, implementing all of the electronics. A possible aluminum alloy for structure.
Maneuverability	can be attached to handheld piece and or user control interface	small, compact. easy to hide and attach to system.	can be attached to a handheld piece	can be attached to handheld piece and or user control interface	not very mobile unless attached to the tractor
Safety	user can control the intensity by visually seeing the need	if it gets wet might short circuit	user can control the intensity by visually seeing the need	if only one high intensity the machine will not get a chance to cool off and work properly	may get confusing with all the controls
Conclusion	best for handheld and for different frequencies	has the capability to program system to switch between more than one motor or frequencies	best for handheld and for different frequencies	is good for handheld but not good for a range or frequencies	might be bulky and not mobile enough but can have a larger combination of controls

Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4	Solution 5
Motor	DC Electric Motor 	Servo Motor 	Offset Mass Motor 	Reciprocating Motor 	Cylinder Coreless Motor 
Frequency Range	has a very high frequency range that is determined by the size	can go up to 50 Hz	typically used for small range frequency	Frequency range depends on overall size of the motor	not strong enough to hit the right frequency
Size	both compact and large depending on what's needed	compact but strong	compact and typically sized to fit into pagers and phones.	can be compact if low frequency is needed	small and may not be strong enough
Programmability	easy to control with Arduino	can be programmed by Arduino	easy to program but difficulty to set to a precise frequency.	easy to program to operate at different speeds and frequencies	easy to program to operate
Conclusion	easy to program and can hit the frequencies needed and is compact for attaching to electronics	easy to program and can hit the frequencies needed and is compact for attaching to electronics	easy to program and is compact for attaching to electronics but can't hit the frequencies needed	easy to program and can hit the frequencies needed but can be too big for a handheld device	easy to program and is compact for attaching to electronics but can’t hit the frequencies needed

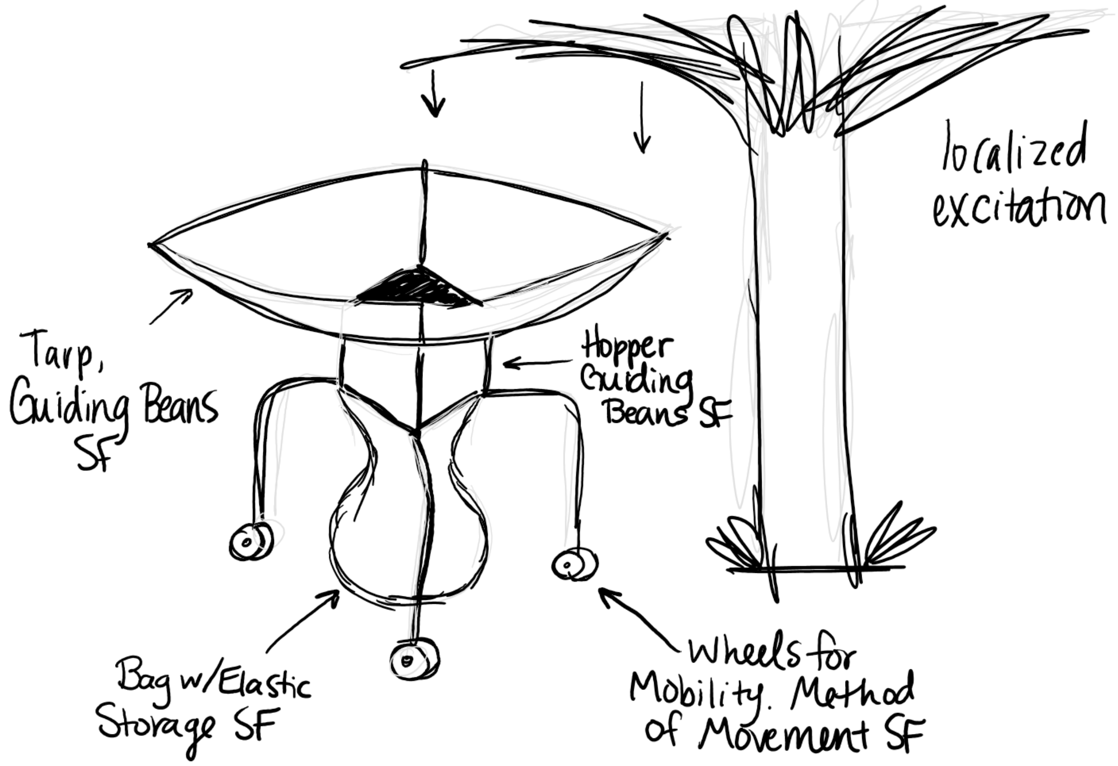
Sub Function	Solution 1	Solution 2	Solution 3	Solutions 4	Solution 5
Method of Movement/Control of Beans	Hollow Piping 	Adjustable Arm Length (threaded fastener) 	Adjustable Arm Length (Crutch Method) 	Solid Piping 	Telescoping Arm 
Weight	Not very heavy, depending on the material being used	Adjustable arm length with attachable parts. Can easily be screwed on to desired length	Adjustable arm length with a clip/button system.	Too Heavy	Not very heavy, depending on the material being used
Cost	cost effective - depends on material	will have to manufacture threading ourselves	cost effective - depends on material	cost effective - depends on material	cost effective - depends on material
Maneuverability	has a set length, may reach high branches or may be difficult to manipulate lower branches	multiple rod segments can be lost or damaged. Carrying all segments may become overbearing	easy to clip in and out of length needed and will be durable enough to stay at length needed	Not as maneuverable because of the weight	the pieces that create length are within the biggest piece
Safety	can bend and tilt if the angle is too much	easy to screw everything in place	when pushing the button the telescoping rod may fall all the way through	Weight could cause injury	easy to screw everything in place
Conclusion	can work for both protecting wires that may need to run the length of the rod but can't retract to be more mobile	will be bad to move all the pieces around after collapsing the rod	strong and durable to have multiple lengths	Not as applicable as the hollow	can grow to the length needed and can be easily brought up and down

ANALYSIS OF MESQUITE BEAN: HYPERLINKS

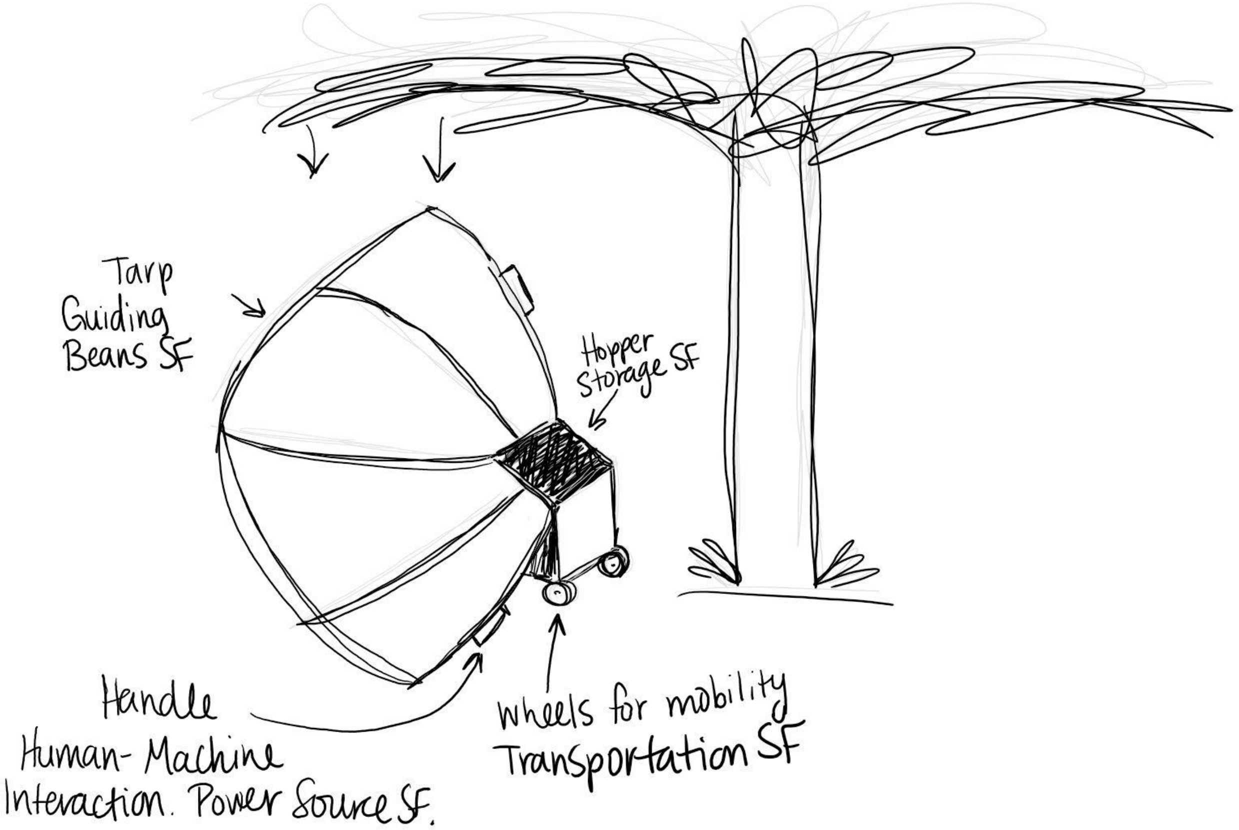
- Mesquite Bean Sample Measurements
- Folder Containing All Mesquite Bean CAD Models
- FEA Frequency Results For Mesquite Bean Models
- Vibrational Analysis Sanity Checks/Calculations
- Comparative Analysis For All Mesquite Bean Frequencies - Theoretical and SolidWorks

CONCEPT VARIANTS: COLLECTION

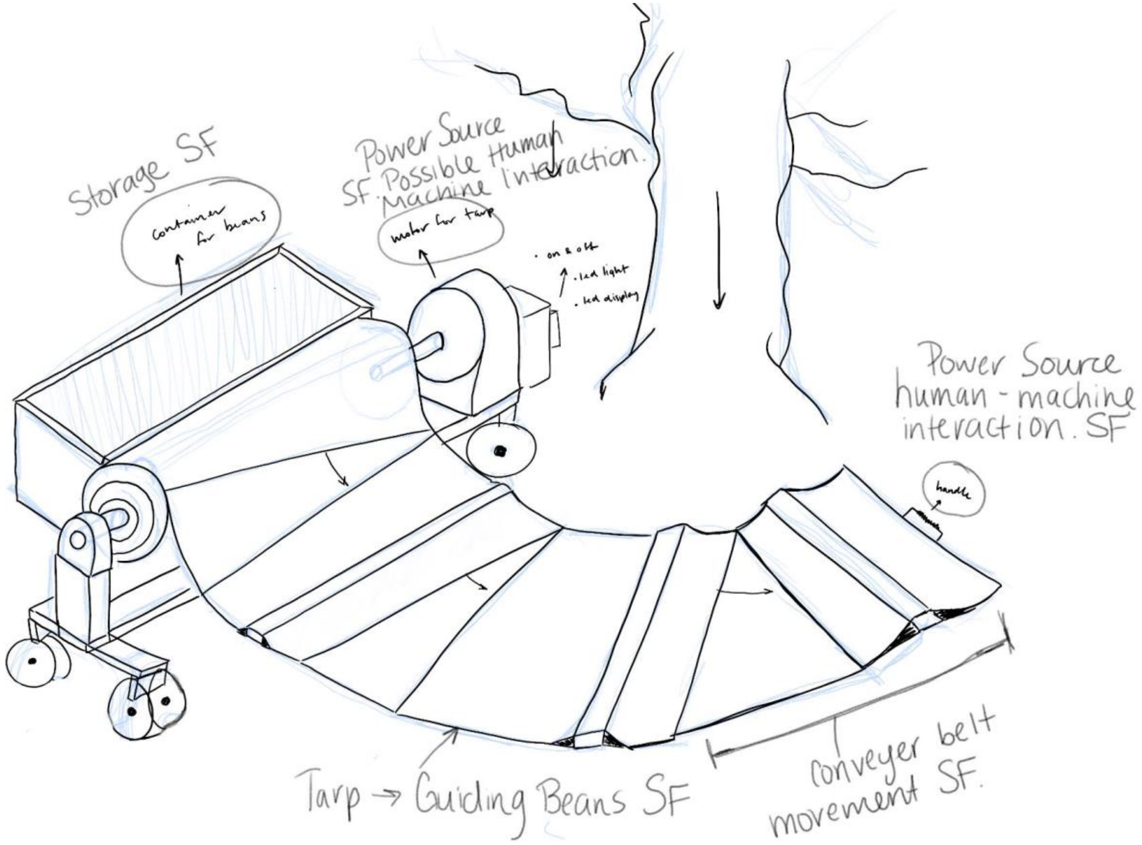
Portable Hopper With Fastening Storage



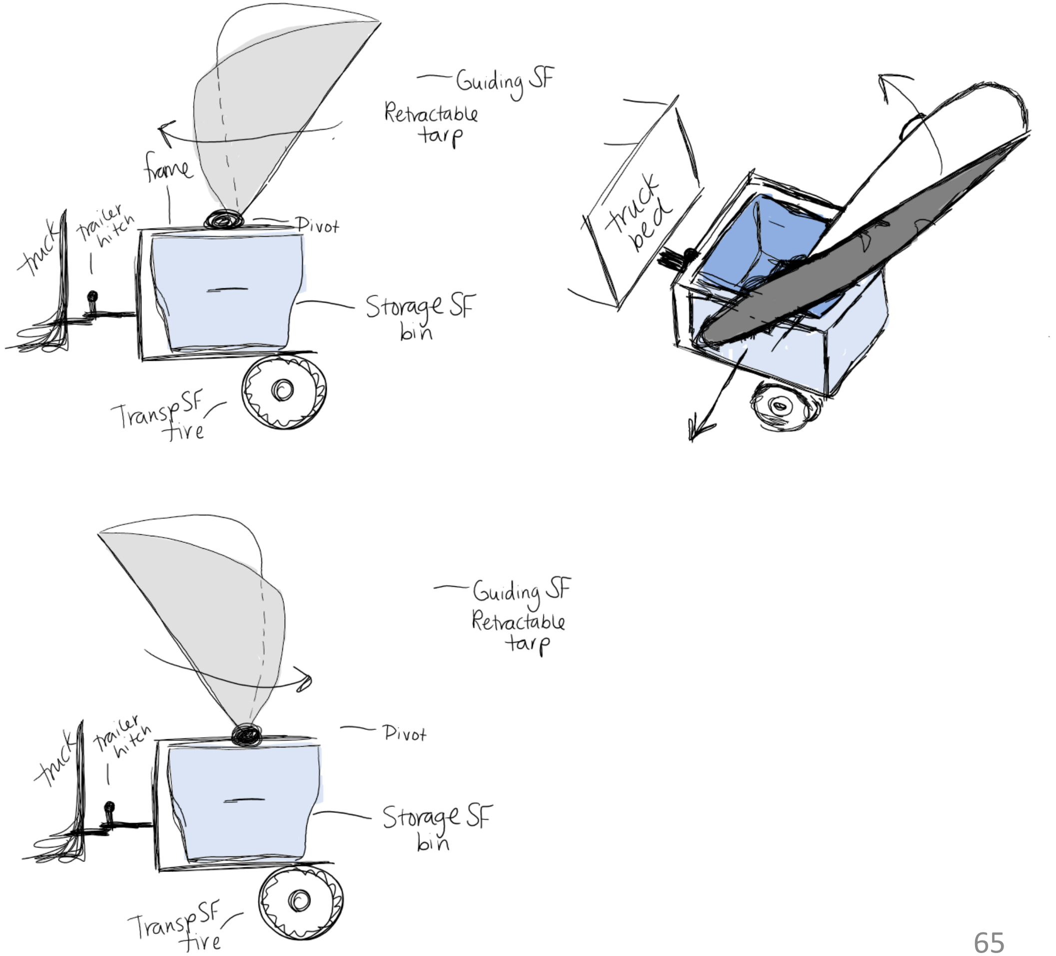
Portable Half-Moon Hopper



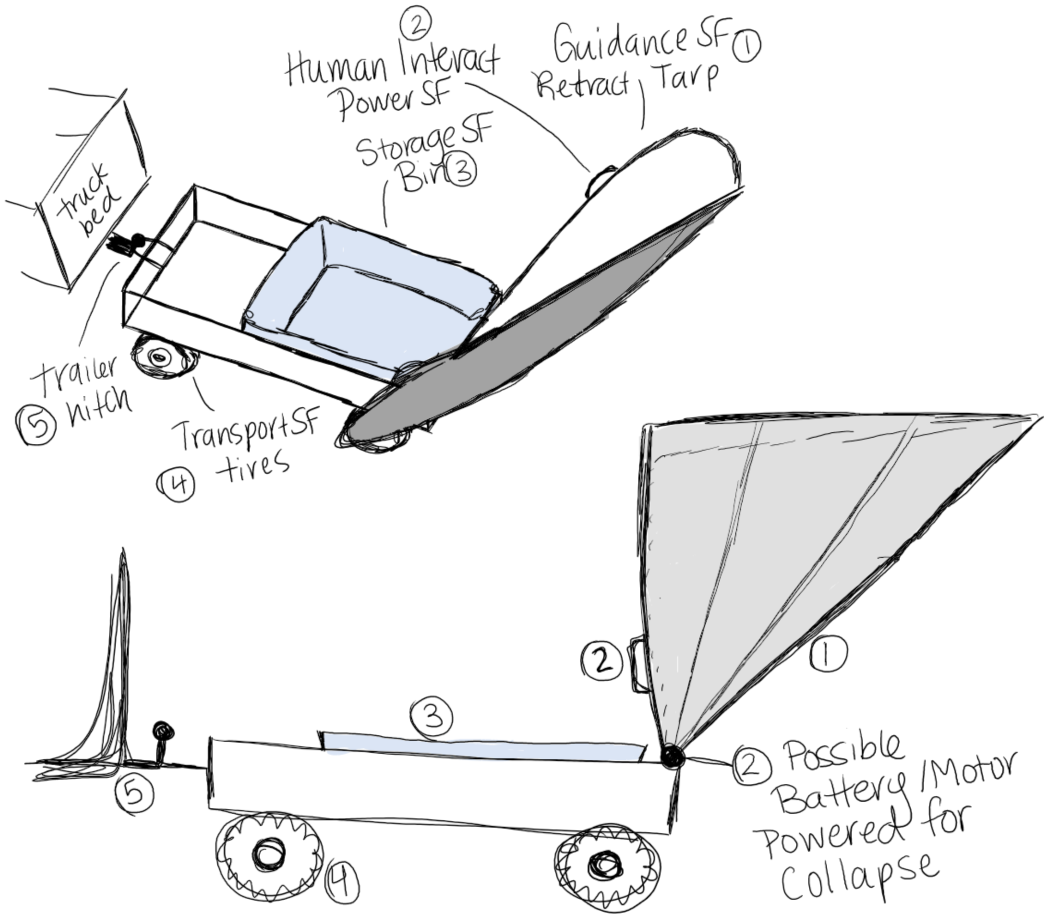
Retractable Conveyer Belt



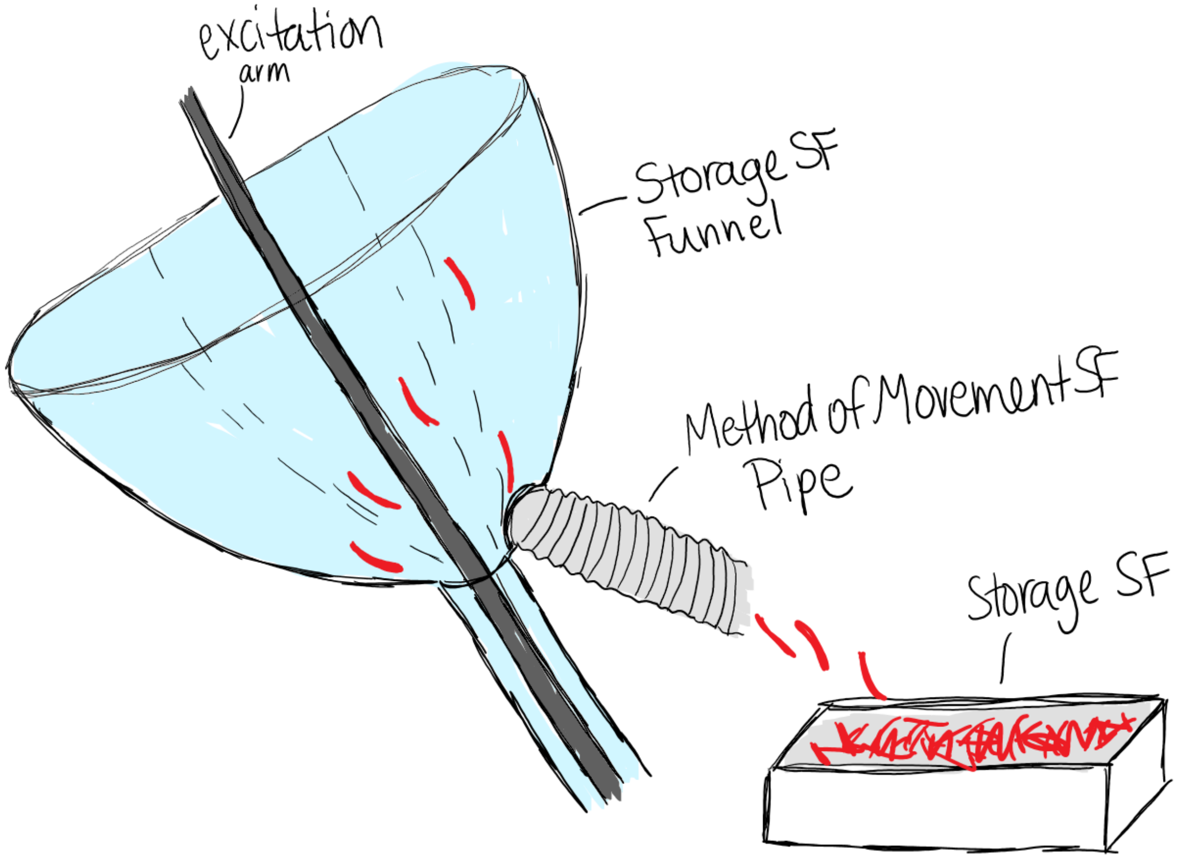
Pivoting Tarp Frame for Replaceable Bins



Retractable Trailer Tarp For Replaceable Bins



Integrated Funnel Collection System

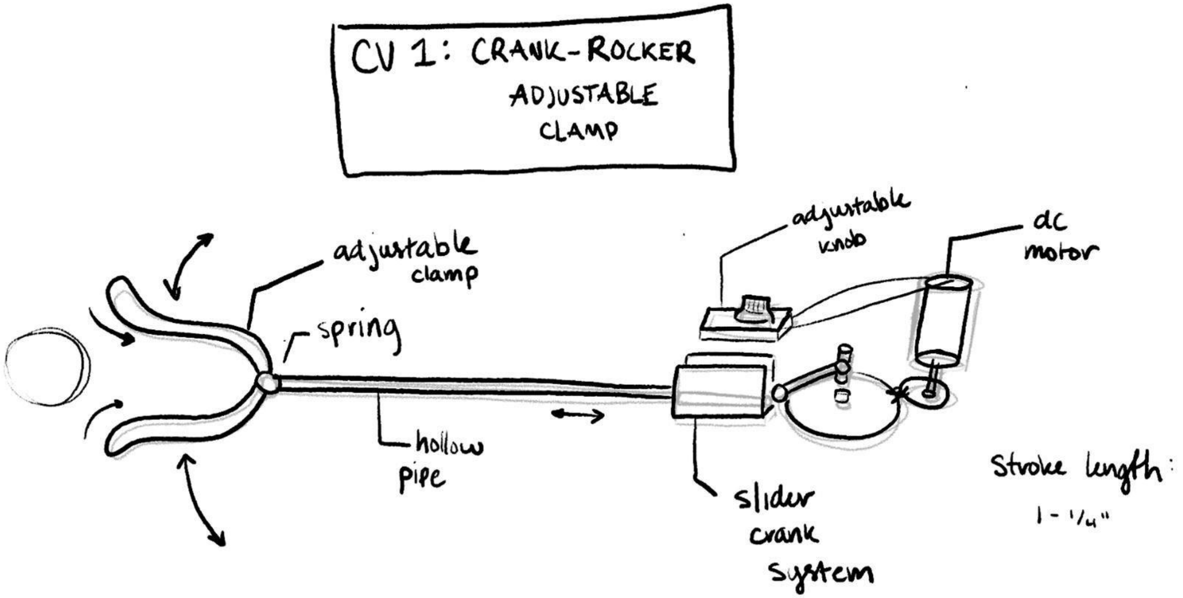


Elimination Process Hyperlink

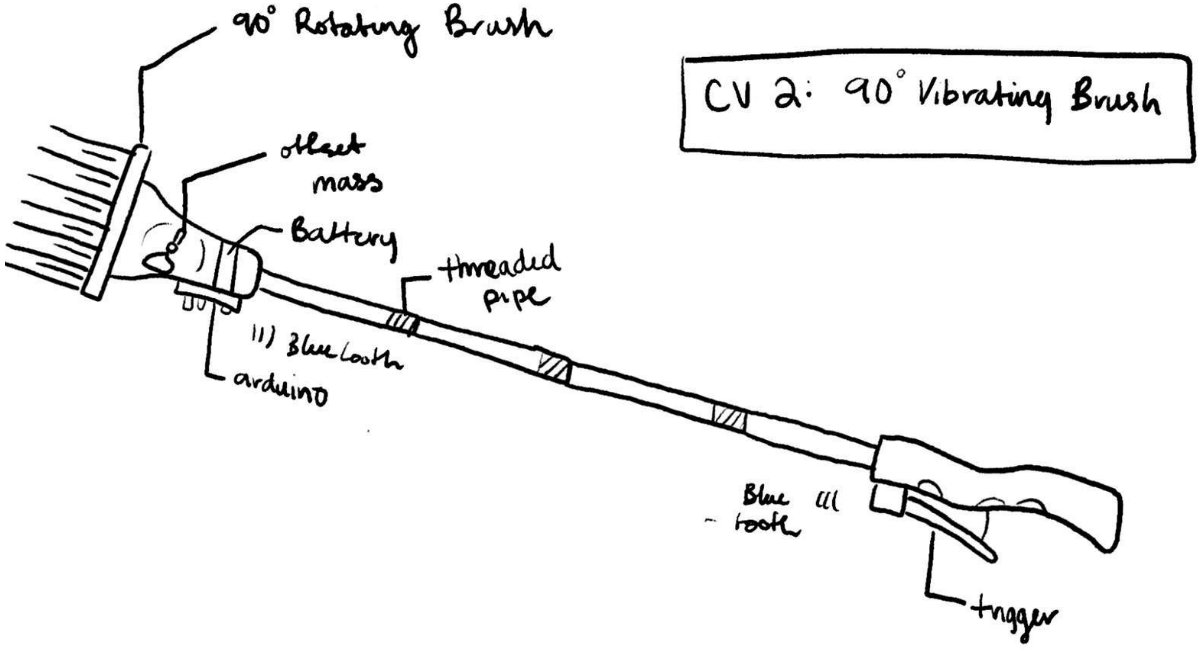
Elimination Datums

CONCEPT VARIANTS: EXCITATION

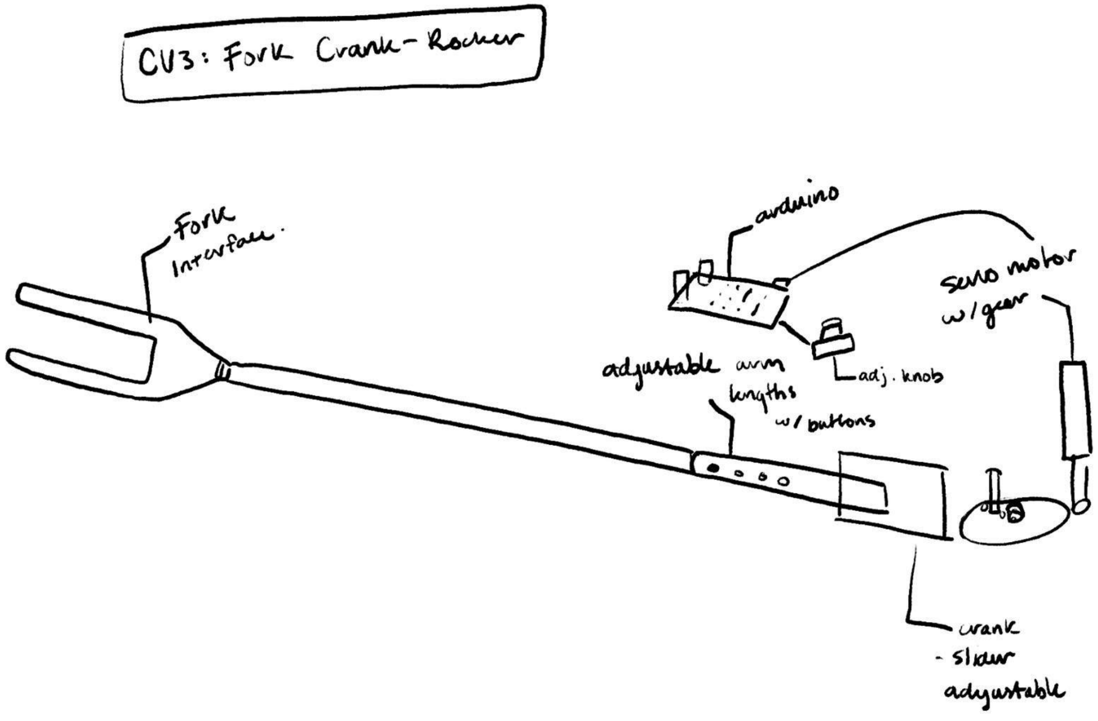
Spring-Loaded Clamp Slider-Crank – Adjustable Knob



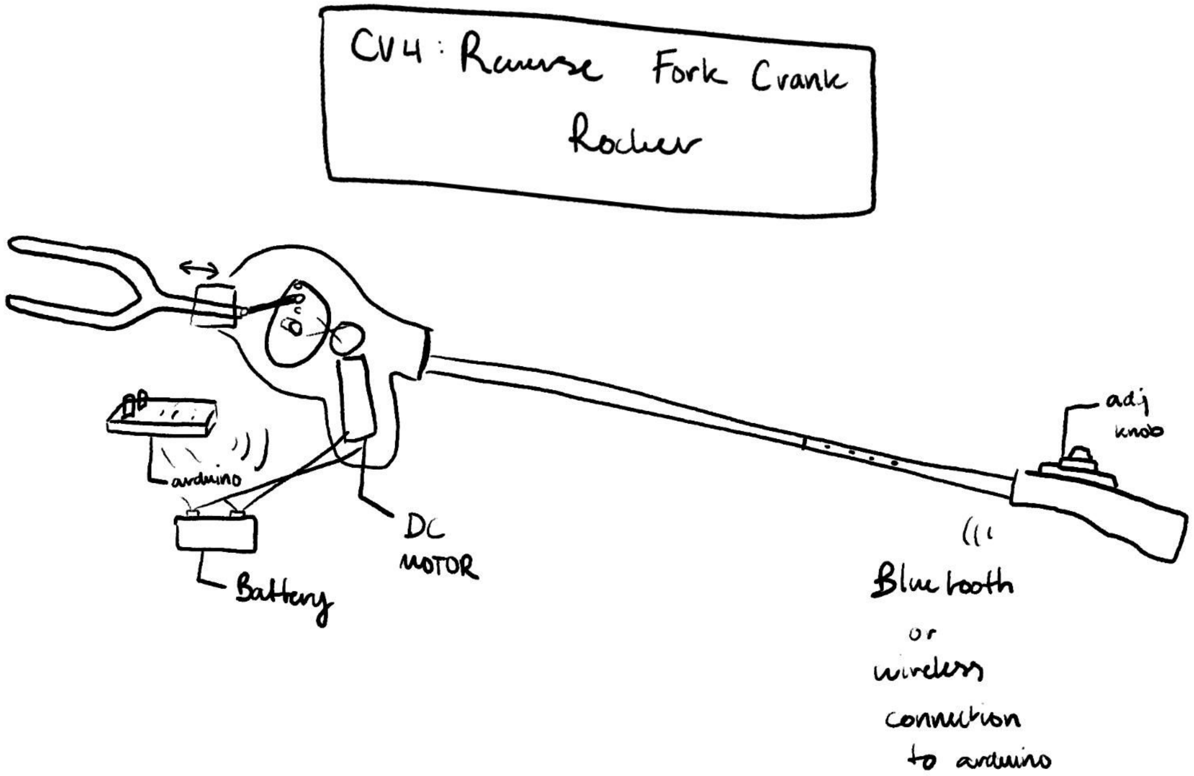
Offset Mass Generated Brush - Trigger



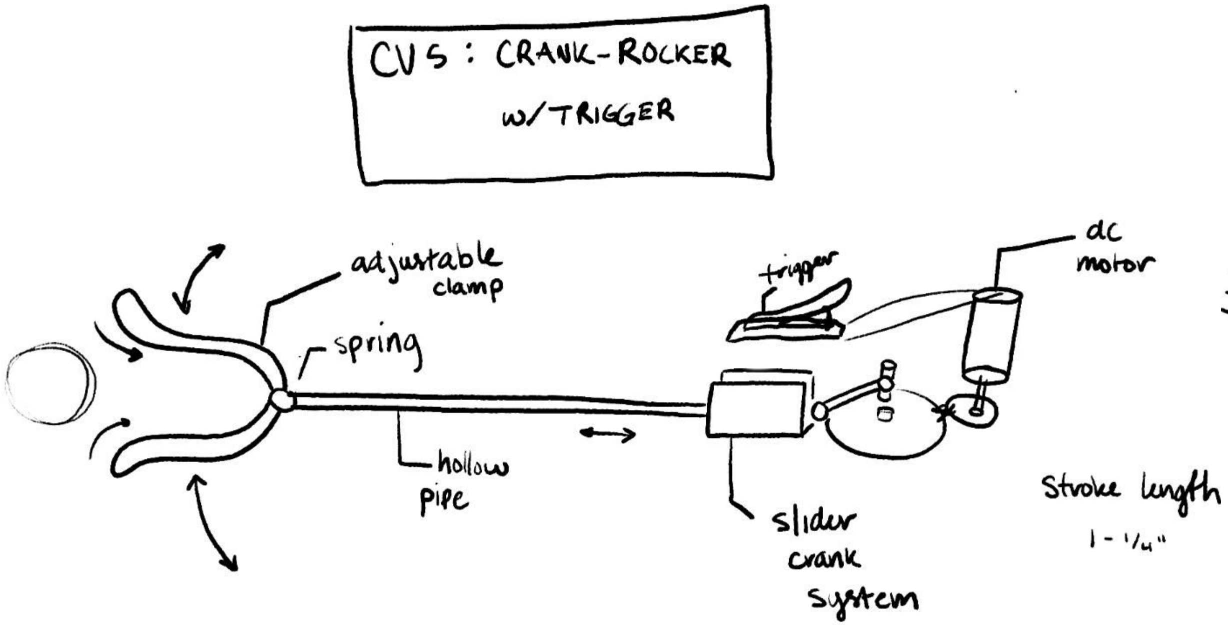
Immovable Fork Slider Crank – Bottom Heavy



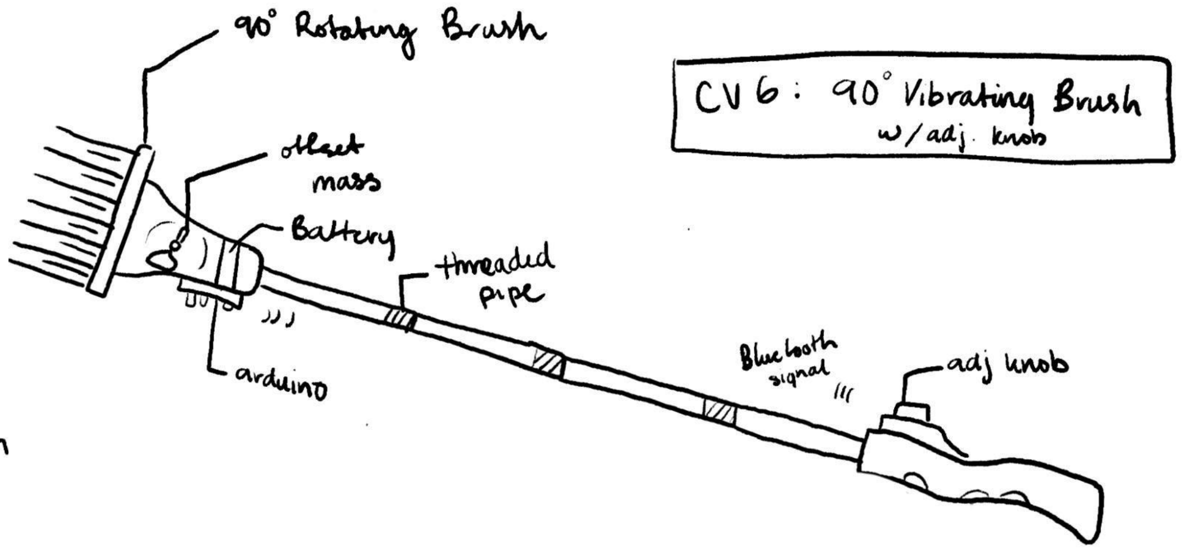
Immovable Fork Slider Crank – Top Heavy



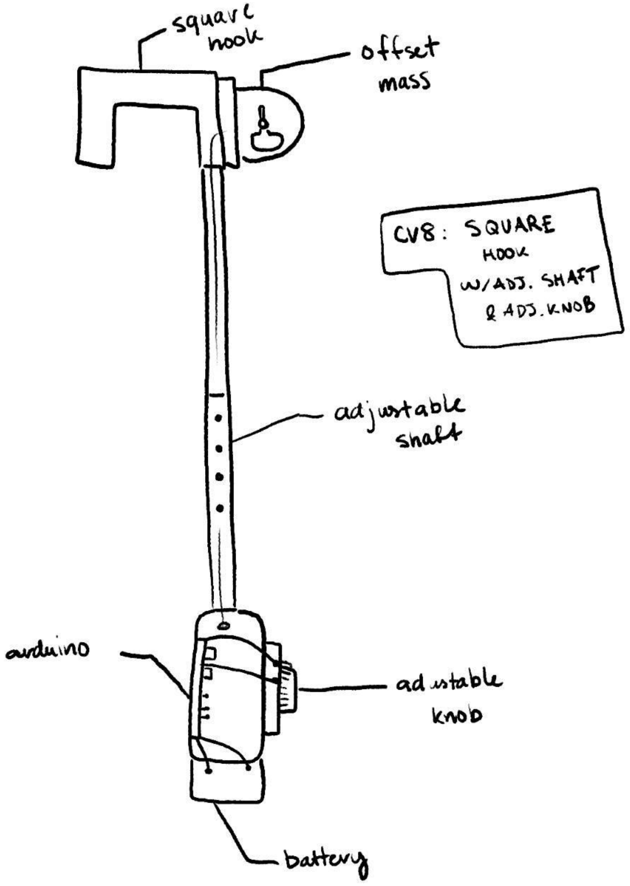
Spring Loaded Slider Crank - Trigger



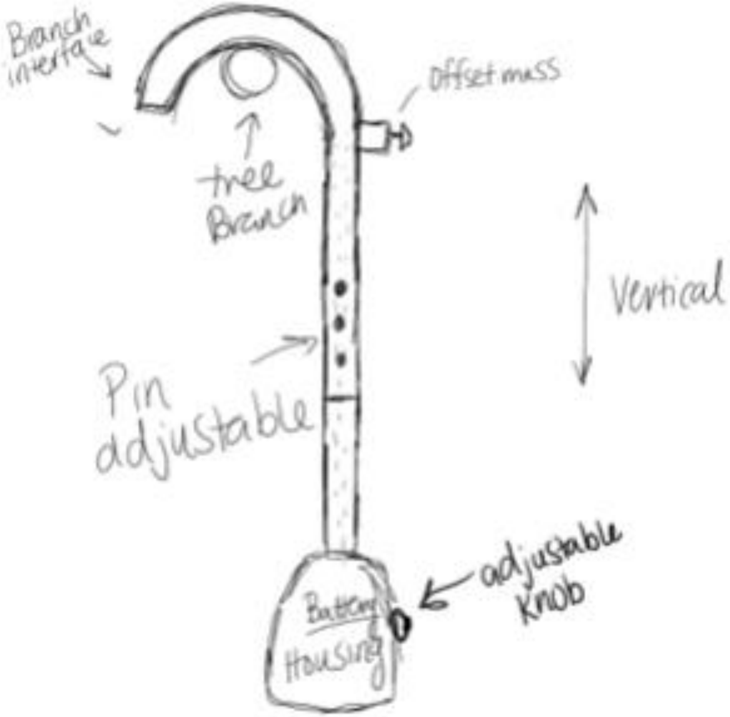
Offset Mass Generated Brush – Adjustable Knob



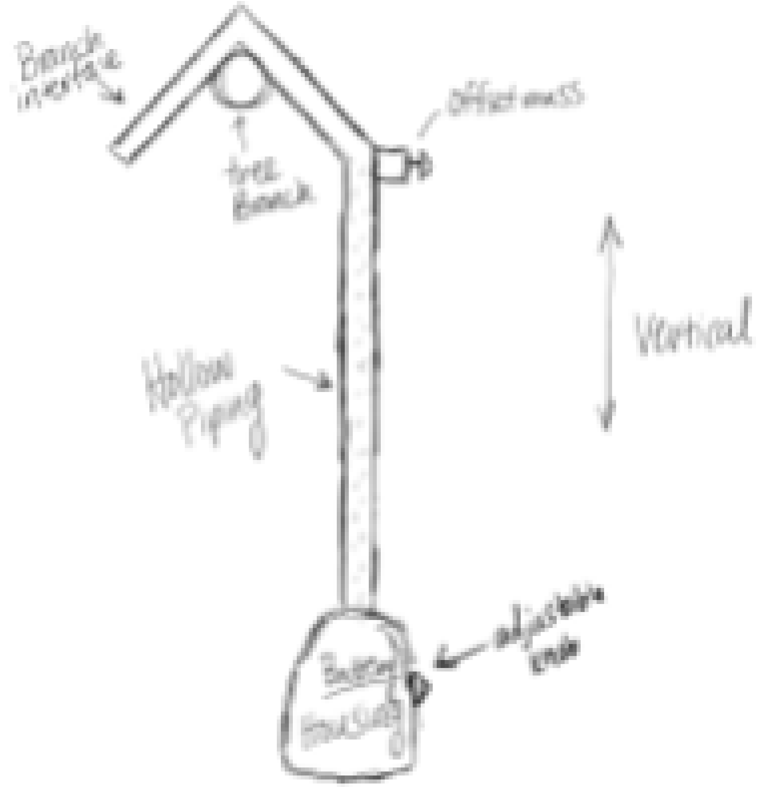
Hanging Square Hook – Adjustable Knob



Hanging Circular Hook – Offset Mass Placement



Hanging Triangluar Hook – Adjustable Knob



Tiger Motor MN4120 400kv Specs.

Item No.	Volts (V)	Prop	Throttle	Amps (A)	Watts (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating temperature(℃)
MN4120 KV400	22.2	T-MOTOR 15*5CF	50%	7.3	162.06	1280	4800	7.90	43
			65%	12.8	284.16	2000	5850	7.04	
			75%	17.8	395.16	2500	6500	6.33	
			85%	23.5	521.70	2970	7000	5.69	
			100%	28.1	623.82	3400	7500	5.45	
		T-MOTOR 16*5.4CF	50%	8.4	186.48	1570	4550	8.42	47
			65%	15.4	341.88	2460	5600	7.20	
			75%	21	466.20	2970	6200	6.37	
			85%	27.6	612.72	3460	6850	5.65	
			100%	32.9	730.38	3850	7100	5.27	
		T-MOTOR 17*5.8CF	50%	9.2	204.24	1730	4400	8.47	56
			65%	17.8	395.16	2670	5400	6.76	
			75%	24.4	541.68	3300	6000	6.09	
			85%	31.7	703.74	3880	6400	5.51	
			100%	37.8	839.16	4250	6800	5.06	
	14.8	T-MOTOR 16*5.4CF	50%	4.8	71.04	760	3300	10.70	33
			65%	8.1	119.88	1160	4000	9.68	
			75%	11.2	165.76	1470	4500	8.87	
			85%	15.1	223.48	1810	4900	8.10	
			100%	18.1	267.88	2030	5250	7.58	
		T-MOTOR 17*5.8CF	50%	5.1	75.48	820	3100	10.86	34
			65%	9.4	139.12	1300	3850	9.34	
			75%	12.8	189.44	1630	4300	8.60	
			85%	17.4	257.52	2030	4700	7.88	
			100%	20.9	309.32	2300	5000	7.44	
		T-MOTOR 18*6.1CF	50%	6.1	90.28	950	2950	10.52	36
			65%	11.5	170.20	1560	3700	9.17	
			75%	15.9	235.32	1940	4100	8.24	
			85%	21	310.80	2340	4500	7.53	
			100%	24.9	368.52	2620	4750	7.11	

Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10 min.

Offset Mass Motor Orientation

- Reference For Offset Mass Motor Orientation