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JME 4110 Final Report - Umbrella Actuator

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Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

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The intention of this project was to improve upon the current methods of actuation required to open and close large patio umbrellas. We have created a prototype that utilizes the assistance of a gas spring enclosed in the umbrella pole to provide the force necessary to open the umbrella while minimizing the force required to close it. This was accomplished through the alteration of an existing, easily purchased, umbrella with a hollow steel pole and the introduction of a low cost gas assist spring. Through the alterations to the pole, and umbrella itself, we were able to attach an internal extension from the canopy hub that coupled with our gas spring. At this coupling location a handle was attached which allows the user actuation of the umbrellas.

JME 4110 Senior Design - Umbrella Actuator

Umbrella Actuator

Phillip James

Juan Mendoza

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1 INTRODUCTION

1.1 VALUE PROPOSITION / PROJECT SUGGESTION

For all users of patio furniture that have shade umbrellas who are dissatisfied with the cumbersome process of raising and lowering the umbrella. Our product provides a safe, quick, effective method for raising or lowering the umbrella without hassle. Unlike the existing methods available, our product removes the awkward process of raising or lowering the umbrella and the possibility of getting hit in the head by the umbrella during operation.

1.2 LIST OF TEAM MEMBERS

- Phillip James
- Juan C. Mendoza
- Brian Sweeney

2 BACKGROUND INFORMATION STUDY

2.1 A SHORT DESIGN BRIEF DESCRIPTION THAT DESCRIBES THE DESIGN PROBLEM

In order to improve upon the current methods of actuation (i.e. winch or manual pushing of the hub) we want to allow the user to stay seated while opening and closing the canopy with relative ease. By such a method the user will be able to stay out of the range of the canopy as it opens and closes which can often end in frustration when simply wanting a quick actuation. This must be accomplished without significantly raising the cost or creating unnecessary actions that may cause reluctance on behalf of the consumer to even try the new method.

2.2 SUMMARY OF RELEVANT BACKGROUND INFORMATION (SUCH AS SIMILAR EXISTING DEVICES OR PATENTS, PATENT NUMBERS, URL'S, ET CETERA)

2.2.1 Patents:

- A copy of a web search result of an existing design that you feel most closely fits the description in the value proposition:

US 6082383 A – Umbrella with actuator sleeve for manual and automatic operation.

Figure 1: US Patent 6082383 A

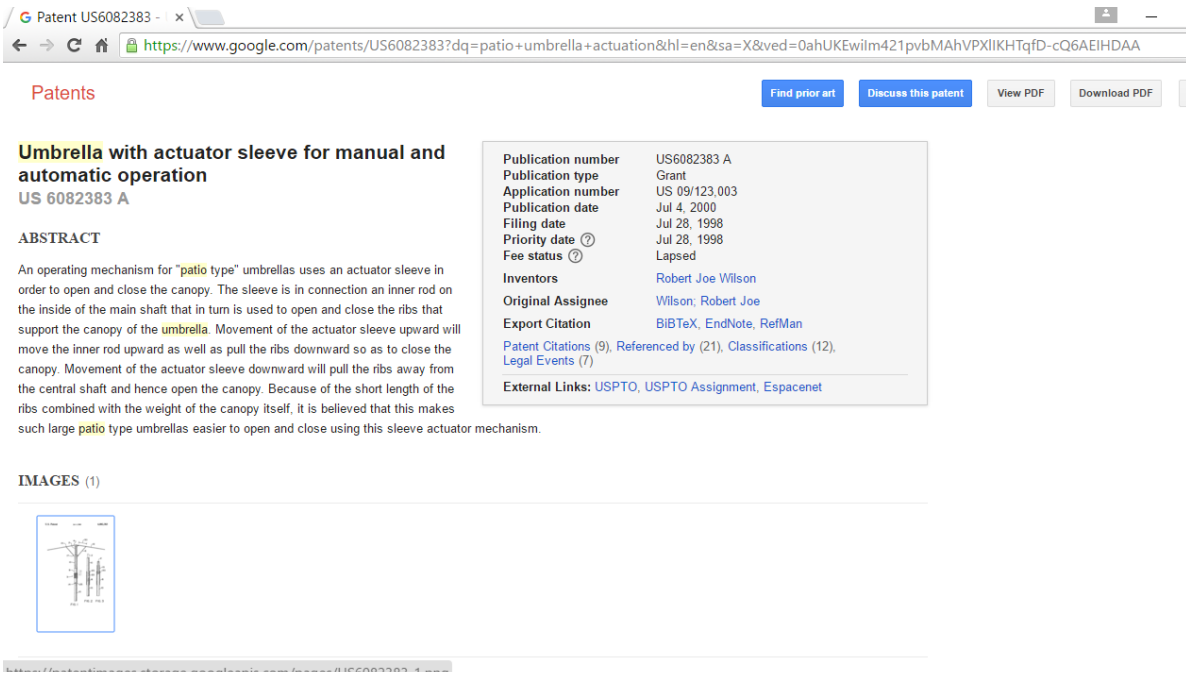
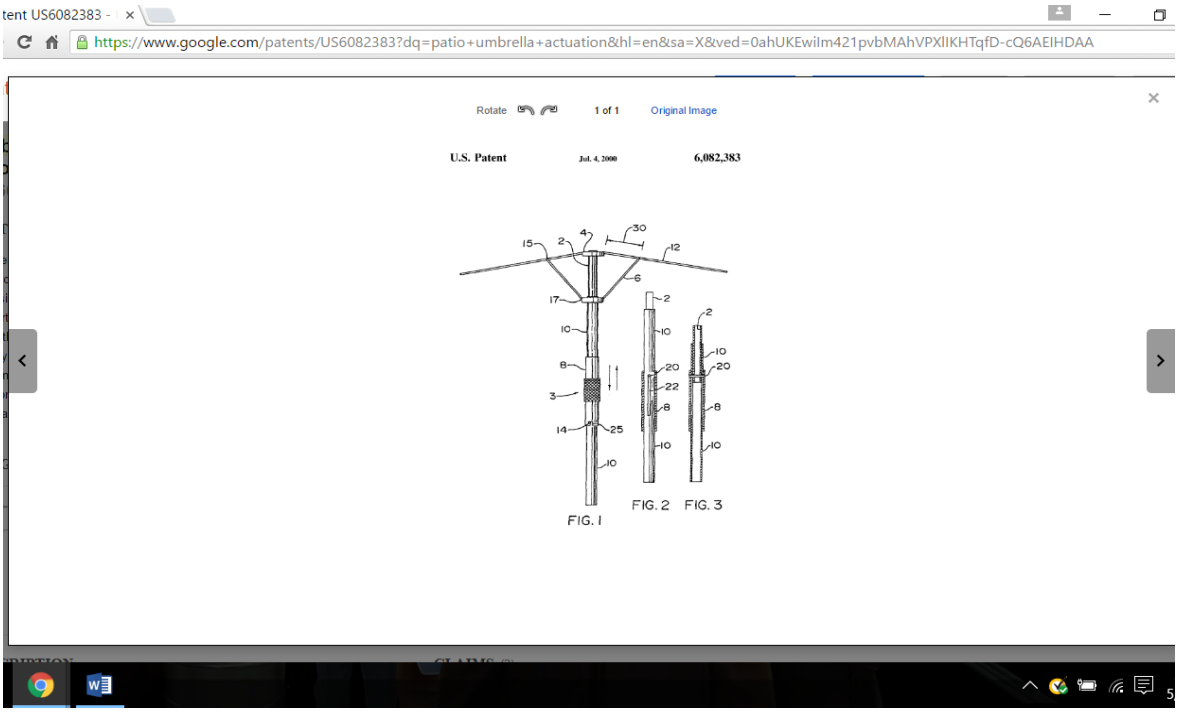


Figure 2: US Patent 6082383 A



- A second web search result of an existing design that you feel most closely fits the description in the value proposition.

US 20080053498A1 – Sunshade that is expanded and folded quickly

Figure 3: US Patent 20080053498A1

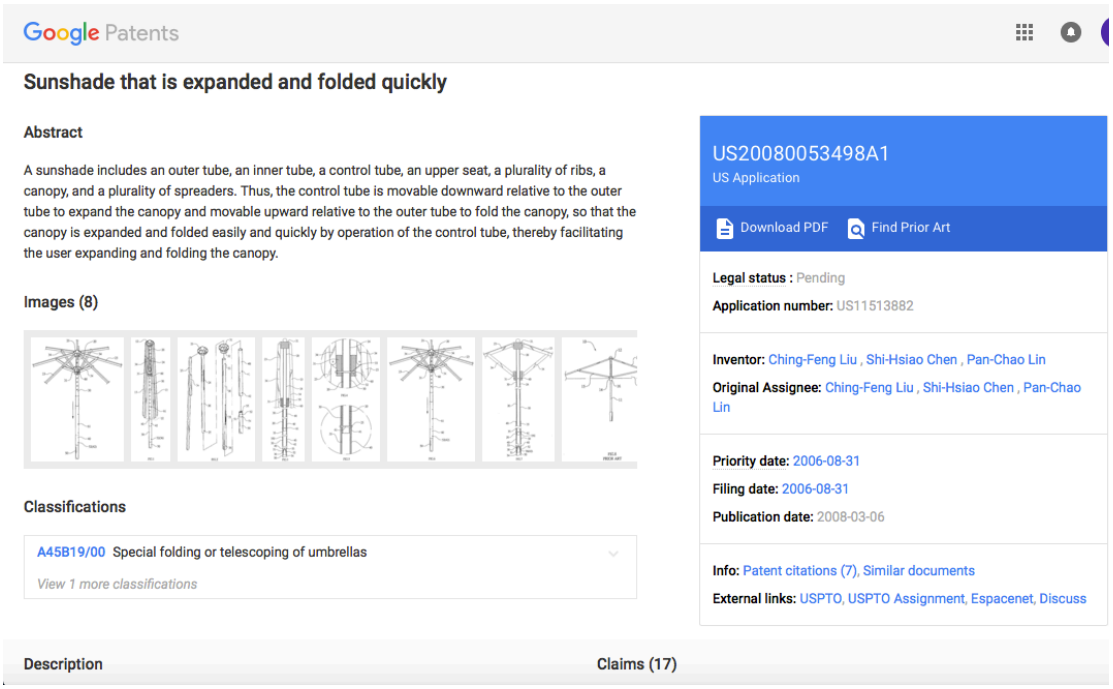
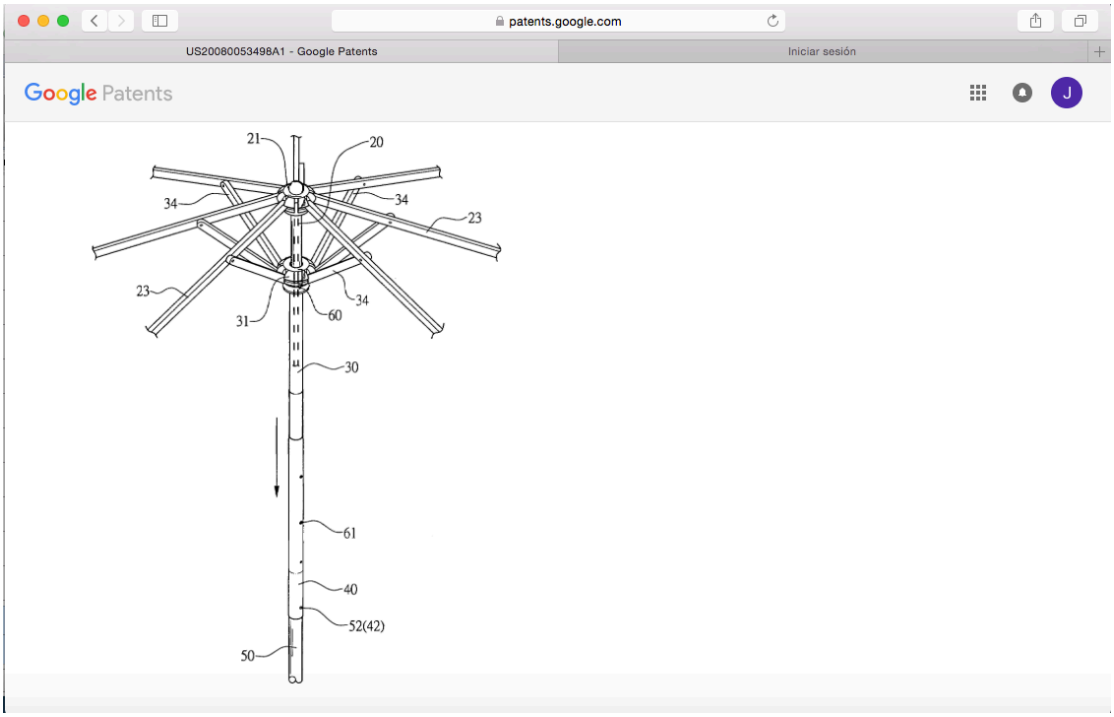


Figure 4: US Patent 20080053498A1



2.2.2. Additional Background Search - risks

A web search result that indicates/suggests the most significant risk to the success of the design process. What would make things not work?

Figure 5: Most significant Risk I

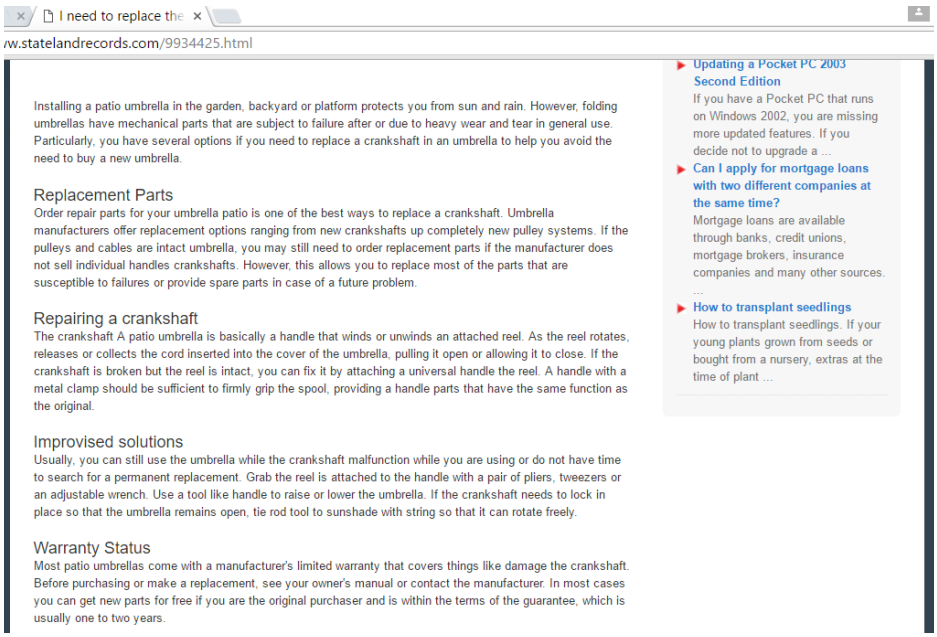


Figure 6: Most significant Risk II

Safety is a critical feature in the design process. Producing a safe product is very important when considering the risks that the product might have. Materials not meeting specifications, requirements not adequately identified, and noncompliance of performance might all present a risk in the engineering design process of this umbrella actuator improvement. Codes and Standards must be followed in order to have a satisfactory outcome.

3 CONCEPT DESIGN AND SPECIFICATION

3.1 USER NEEDS, METRICS, AND QUANTIFIED NEEDS EQUATIONS.

3.1.1 Record of the user needs interview

Customer Needs Interview

Please, refer to Appendix for full customer statement.

Table 1: Customer Needs Interview

Project/Product Name: Umbrella Actuator (UA)			
Customer: Dr. Jakiela; 4110 Professor. Address: Washington University Willing to do follow up? Yes Type of user: Anyone with a Patio umbrella		Interviewer(s): Phillip James, Juan Mendoza, Brian Sweeney; 4110 students Date: June 9, 2016 Currently uses: Never owned an umbrella	
Question	Customer Statement	Interpreted Need	Importance
What types of patio umbrellas are you familiar with?	Not familiar at all. Do not own one. Will never get one. Have some experience using them at resorts, and my responses are informed by those experiences	Expand market; make all customers desire an Umbrella actuator. (Need not included)	2
What would you look for in a new patio umbrella? What are important features?	Light weight, easy/fast collapse. Take down quickly. Speed is less of an issue, but want it to be physically easy to erect and use. UA should have good stability	UA is lightweight. UA collapses quickly (storage) UA is easy to actuate UA is stable	4 5 5 3
Have you ever had to either quickly raise or lower a patio umbrella? What do you consider a quick time?	Not sure. Lowering more important than rising quickly.	UA lowers quickly	5
Have you ever encountered a problem with raising or lowering the umbrella?	The torques/forces that you have to put on a hand crank tend to destabilize the system.	Umbrella does not use Hand Crank	5

If you bought new patio furniture would you rather reuse the same patio umbrella or purchase a new one?	I would likely just get a new umbrella that matches all the other patio furniture.	UA has a stylish design UA is affordable	3
Do you find having to clear the table before actuating the umbrella a burden?	Table should not be clear for umbrella to go up and down.	UA can be close at any moment	2
If the actuation was beneath the table would you prefer it to be operated by foot or hand	I think actuation by hand is safer and better	UA is actuated by hand	4
How important is it for you that the umbrella works safely?	Really important. An absolute must-have	UA is a safe and reliable product.	5

NOTE: Please refer to Appendix interview document in order to read full interview with Professor Mark J. Jakiela. Some questions were excluded from this document since they didn't provide new user needs. Those questions were used to expand already defined ideas.

3.1.2 List of identified metrics

Needs Table for Umbrella Actuator (UA) - initial

Table 2: Needs table for UA - initial

Need Number	Need	Importance
1	UA is light weight	4
2	UA collapses quickly (storage/installation)	5
3	UA is easy to actuate	5
4	UA is stable	4
5	UA lowers quickly	5
6	UA has a stylish design	3
7	UA can be close at any moment	2
8	UA is actuated by hand	4
9	UA is a safe and reliable product.	5
10	UA is affordable	3

3.1.3 Table/list of quantified needs equations

Metrics Table for Umbrella Actuator - initial

Table 3: Metrics Table for UA - initial

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1	Weight	Pounds (lb.)	15	50
2	2,5,7	Time	Seconds (s)	1	10
3	3	Force	Lb.	20	100
4	6	Aesthetics	Integer	1	5
5	8	User effort	Integer	0	1
6	9	Level of Safety	Integer	0	5
7	10	Currency	Dollars ($)	50	150
8	4	Stability	Integer	1	10

3.2 FOUR (4) CONCEPT DRAWINGS

Figure 7: Concept Drawing #1

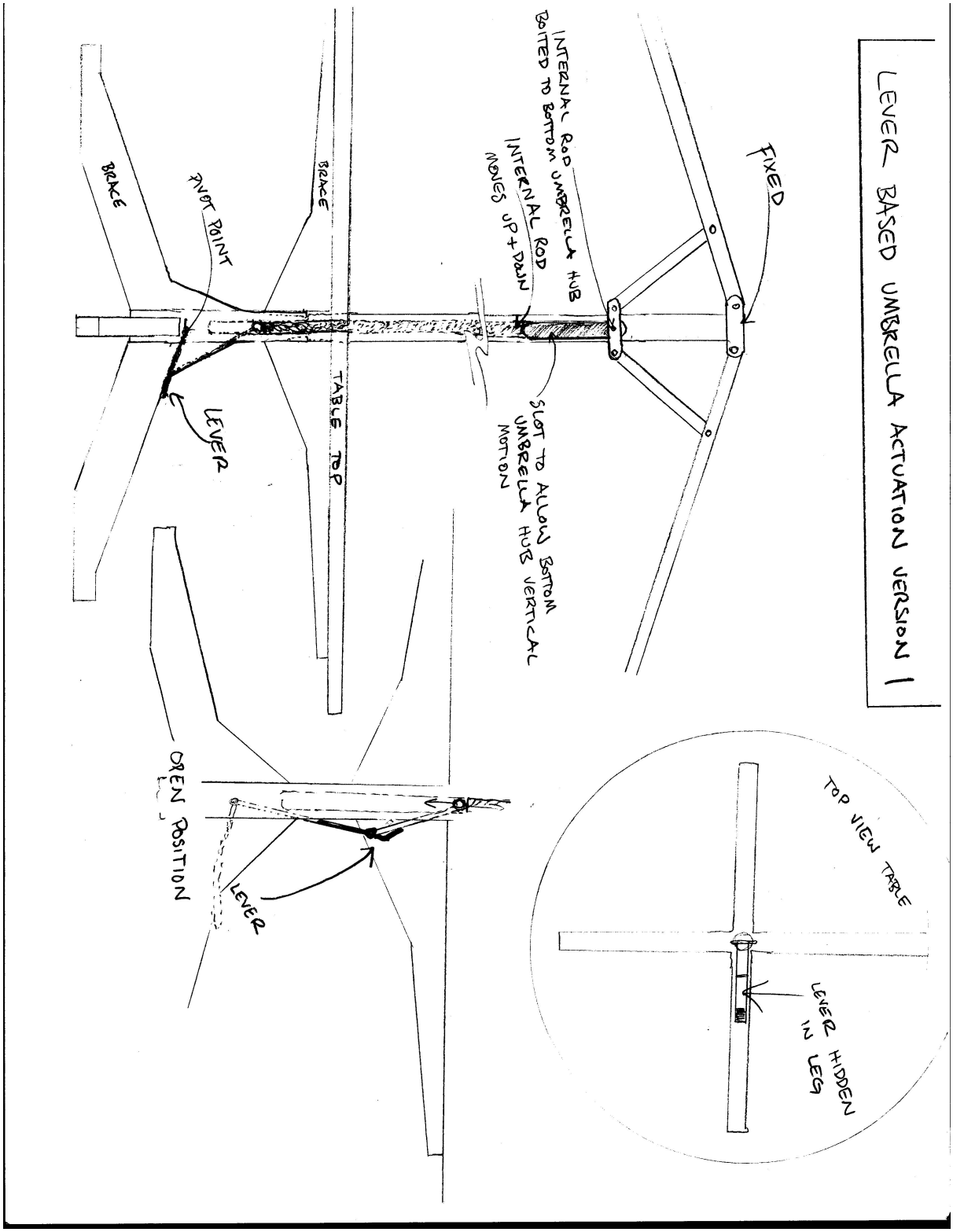


Figure 8: Concept Drawing #2

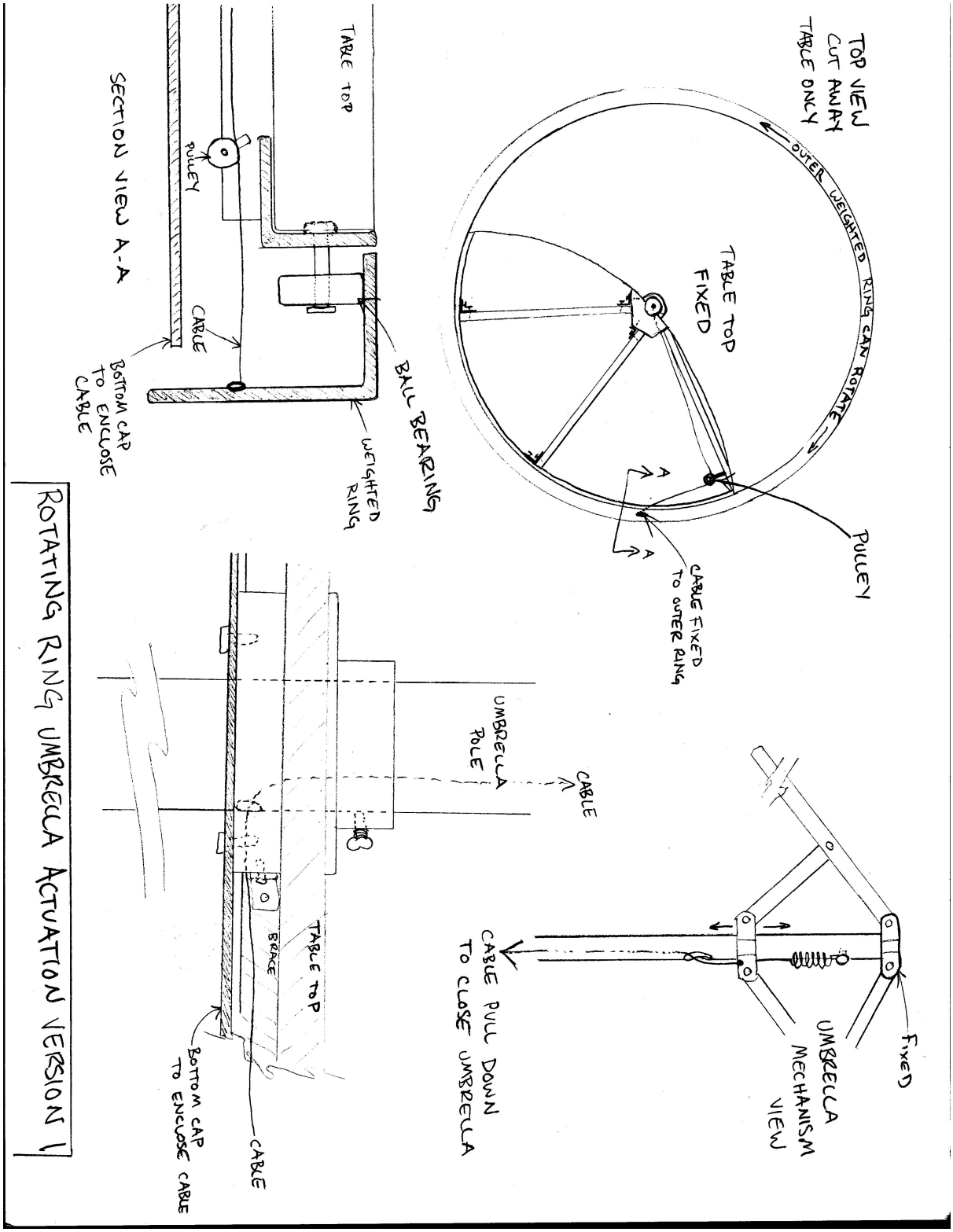


Figure 9: Concept Drawing #3

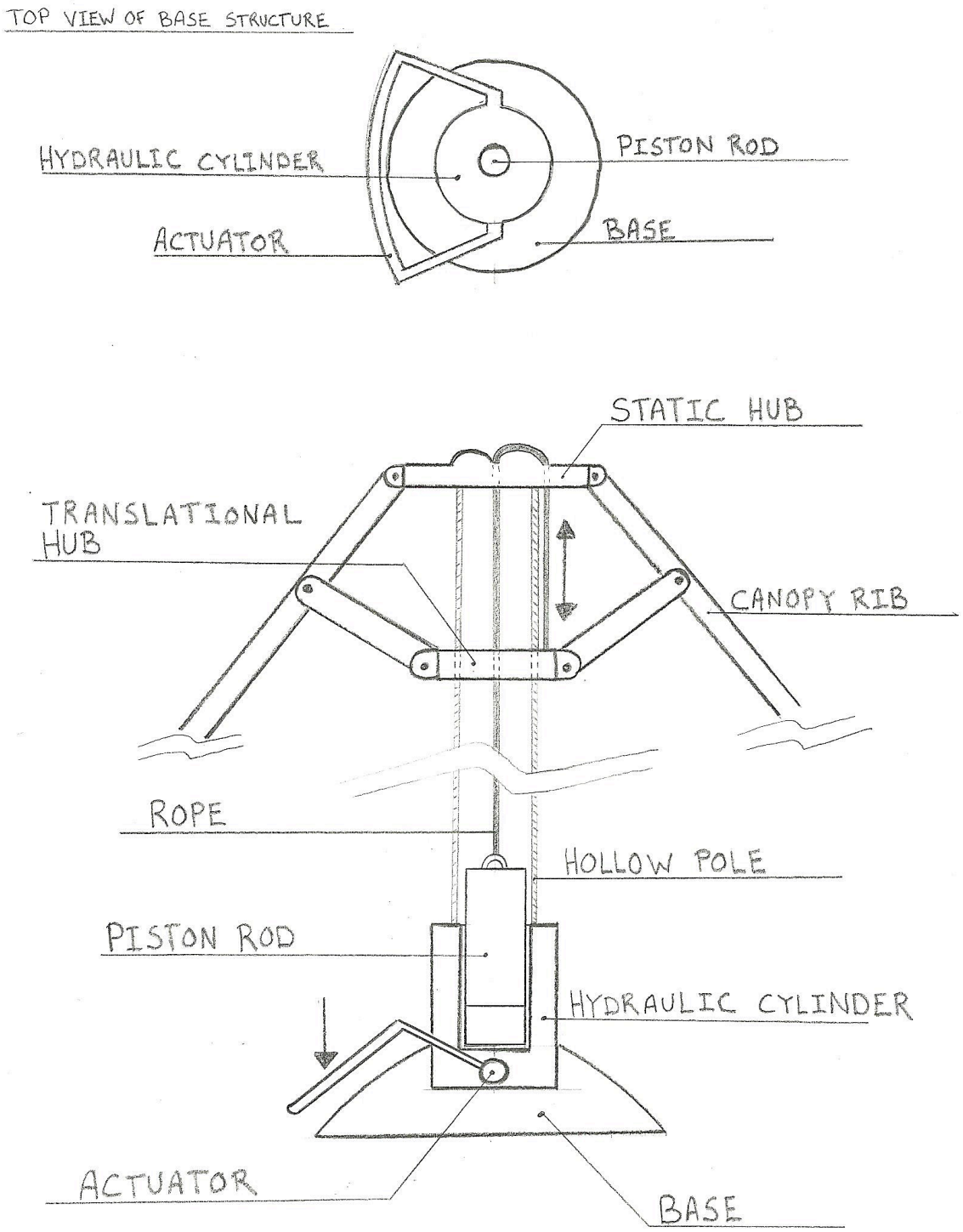


Figure 10: Concept Drawing #4

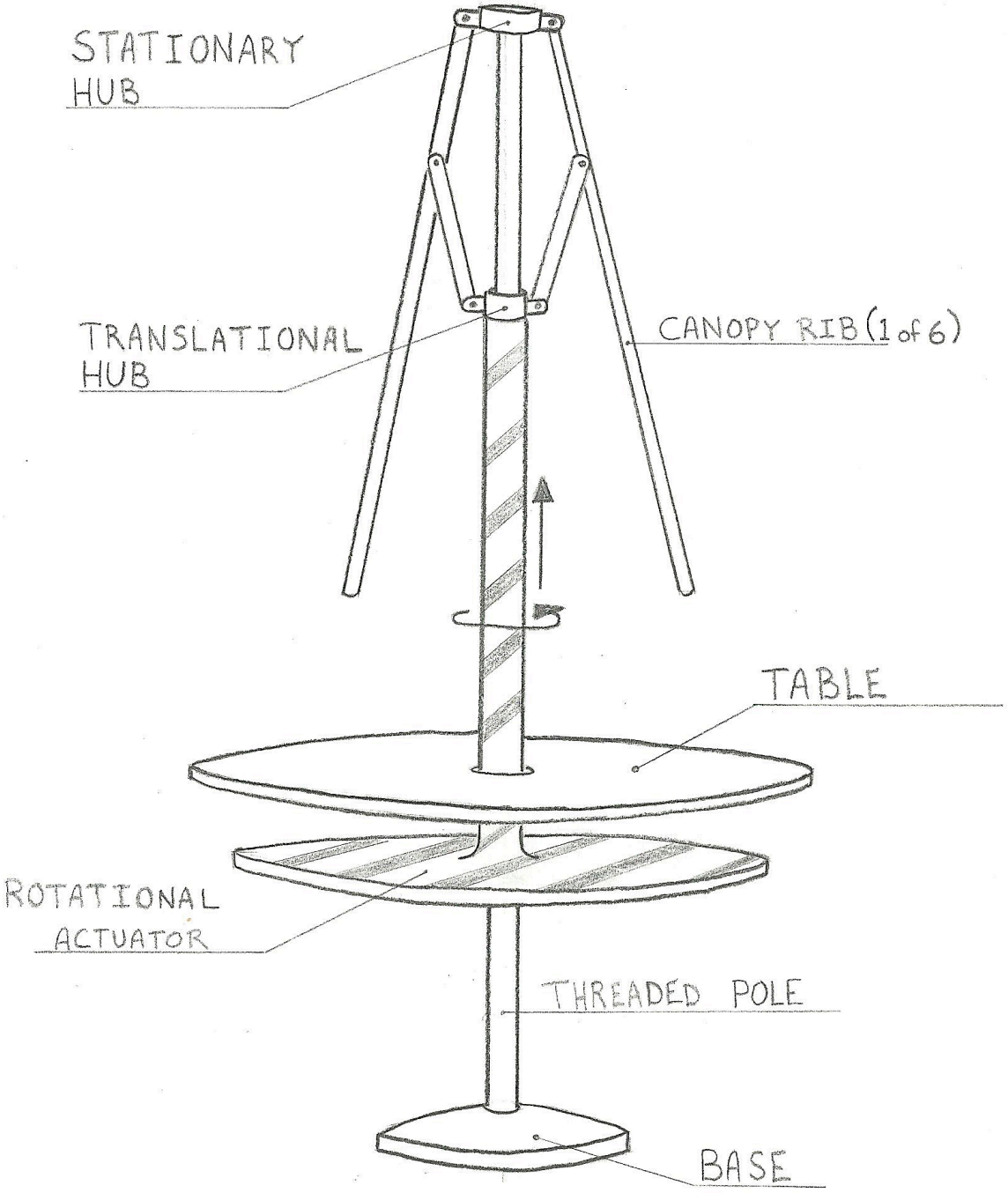
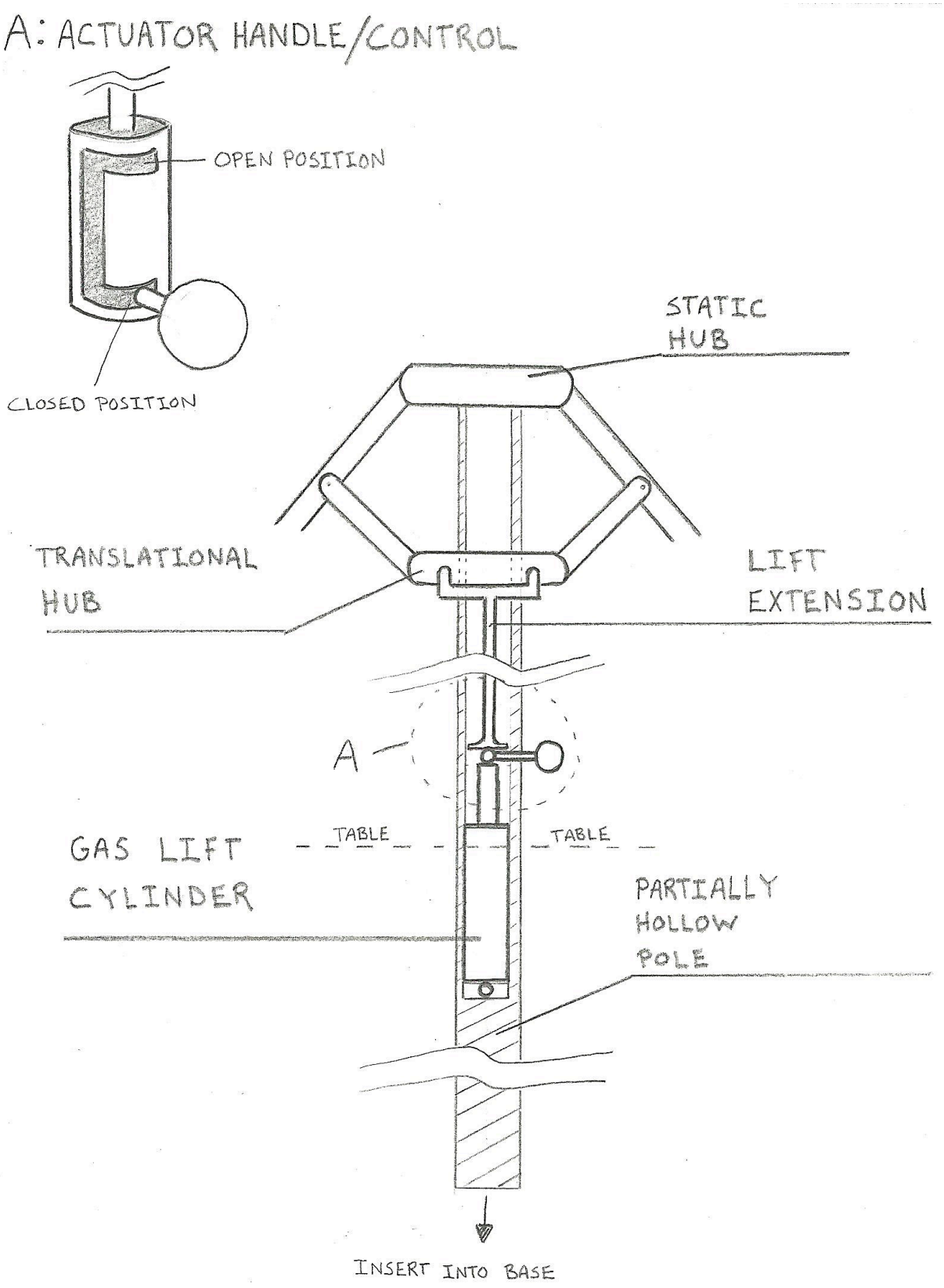


Figure 11: Concept Drawing #3 - redesigned - revised



3.3 A CONCEPT SELECTION PROCESS.

3.3.1 Concept scoring (not screening)

Table 4: Concept Scoring – Design #1

Umbrella Actuator (Design #1) Lever Based Umbrella		Metric										
		Weight	Time	Force	Aesthetics	User Effort	Level of Safety	Currency	Stability	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8			
1	UA is light weight	1								1	0.1	0.1
2	UA collapses quickly (storage)		1							1	0.125	0.125
3	UA is easy to actuate			1						0.875	0.125	0.109375
4	UA is stable								1	1	0.1	0.1
5	UA lowers quickly		1							1	0.125	0.125
6	UA has a stylish design				1					0.75	0.075	0.05625
7	UA can be close at any moment		1							1	0.05	0.05
8	UA is actuated by hand					1				0.5	0.1	0.05
9	UA is a safe and reliable product						1			0.4	0.125	0.05
10	UA is affordable							1		0.7	0.075	0.0525
Units		lb	seconds	lbf	integer	integer	integer	dollars	integer	Total Happiness		0.818125
Best Value		10	5	20	5	1	5	50	10			
Worst Value		30	10	100	1	5	0	150	1		1	
Actual Value		10	5	30	4	3	2	80	6			
Normalized Metric Happiness		1	1	0.875	0.75	0.5	0.4	0.7	0.55556			

Table 5: Concept Scoring – Design #2

Umbrella Actuator (Design #2)		Metric										
		Weight	Time	Force	Aesthetics	User Effort	Level of Safety	Currency	Stability	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8			
1	UA is light weight	1								1	0.1	0.1
2	UA collapses quickly		1							0.6	0.125	0.075
3	UA is easy to actuate			1						0.75	0.125	0.09375
4	UA is stable								1	1	0.1	0.1
5	UA lowers quickly		1							0.6	0.125	0.075
6	UA has a stylish design				1					0.75	0.075	0.05625
7	UA can be close at any moment									0	0.05	0
8	UA is actuated by hand		1			1				1.35	0.1	0.135
9	UA is a safe and reliable product						1			1	0.125	0.125
10	UA is affordable							1		0.5	0.075	0.0375
Units		lb	seconds	lbf	integer	integer	integer	dollars	integer	Total Happiness		0.7975
Best Value		10	5	20	5	1	5	50	10			
Worst Value		30	10	100	1	5	0	150	1		1	
Actual Value		10	7	40	4	2	5	100	5			
Normalized Metric Happiness		1	0.6	0.75	0.75	0.75	1	0.5	0.44444			

Table 6: Concept Scoring – Design #3

Umbrella Actuator (Design #3)		Metric										
		Weight	Time	Force	Aesthetics	User Effort	Level of Safety	Currency	Stability	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8			
1	UA is light weight	1								0.25	0.1	0.025
2	UA collapses quickly		1							0.2	0.125	0.025
3	UA is easy to actuate			1						0.875	0.125	0.109375
4	UA is stable								1	1	0.1	0.1
5	UA lowers quickly		1							0.2	0.125	0.025
6	UA has a stylish design				1					0.75	0.075	0.05625
7	UA can be close at any moment		1							0.2	0.05	0.01
8	UA is actuated by hand					1				0.75	0.1	0.075
9	UA is a safe and reliable product						1			0.4	0.125	0.05
10	UA is affordable							1		0.05	0.075	0.00375
Units		lb	seconds	lbf	integer	integer	integer	dollars	integer	Total Happiness		0.479375
Best Value		10	5	20	5	1	5	50	10			
Worst Value		30	10	100	1	5	0	150	1		1	
Actual Value		25	9	30	4	2	2	145	7			
Normalized Metric Happiness		0.25	0.2	0.875	0.75	0.75	0.4	0.05	0.66667			

Table 7: Concept Scoring – Design #4

Umbrella Actuator (Design #4)		Metric										
		Weight	Time	Force	Aesthetics	User effort	Level of Safety	Currency	Stability	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8			
1	UA is light weight	1								0.05	0.1	0.005
2	UA collapses quickly		1							0	0.125	0
3	UA is easy to actuate			1						0.25	0.125	0.03125
4	UA is stable								1	1	0.1	0.1
5	UA lowers quickly			1						0.25	0.125	0.03125
6	UA has a stylish design				1					0	0.075	0
7	UA can be close at any moment			1						0.25	0.05	0.0125
8	UA is actuated by hand					1				0	0.1	0
9	UA is a safe and reliable product						1			1	0.125	0.125
10	UA is affordable							1		0	0.075	0
Units		lb	seconds	lbf	integer	integer	integer	dollars	integer	Total Happiness		0.305
Best Value		10	5	20	5	1	5	50	10			
Worst Value		30	10	100	1	5	0	150	1			
Actual Value		29	10	80	1	5	5	150	4			
Normalized Metric Happiness		0.05	0	0.25	0	0	1	0	0.33333			

1

Table 8: Concept Scoring – Design #3 – redesigned - revised

Umbrella Actuator (Design #3) Redesigned revised		Metric										
		Weight	Time	Force	Aesthetics	User Effort	Level of Safety	Currency	Stability	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8			
1	UA is light weight	1								1	0.1	0.1
2	UA collapses quickly (storage)		1							1	0.125	0.125
3	UA is easy to actuate			1						0.9375	0.125	0.1171875
4	UA is stable								1	1	0.1	0.1
5	UA lowers quickly		1							1	0.125	0.125
6	UA has a stylish design				1					1	0.075	0.075
7	UA can be close at any moment		1							1	0.05	0.05
8	UA is actuated by hand					1				0.75	0.1	0.075
9	UA is a safe and reliable product						1			0.4	0.125	0.05
10	UA is affordable							1		0.9	0.075	0.0675
Units		lb	seconds	lbf	integer	integer	integer	dollars	integer	Total Happiness		0.8846875
Best Value		10	5	20	5	1	5	50	10			
Worst Value		30	10	100	1	5	0	150	1		1	WINNER
Actual Value		10	5	25	5	2	2	60	6			
Normalized Metric Happiness		1	1	0.9375	1	0.75	0.4	0.9	0.55556			

3.3.2 Preliminary analysis of each concept's physical feasibility

Design #1

The lever actuated umbrella design is a feasible method for achieving the required end result. The overall design is somewhat simple in general concept although some specific concerns present themselves when looking closely at what would be required to make this design work at the desire performance. As far as meeting the main requirements are concerned, the umbrella could be raised and lowered quickly while staying safely out of the way of the operation. Also, the table would not need to be emptied before operation. The challenges include fully understanding the lever geometry, which might need to include a hinged or linked extension to make actuation easier without needing to bend over. Another potential challenge is in the easy removal of the umbrella, this would require some sort of lock to release the umbrella from the table. Possibly the greatest challenges of this design are found in the manufacturing process of the base or legs of the design, as one of the 4 legs is required to hide the lever for aesthetic reasons. Additionally, this lever needs to be connected to the base and a second arm of the lever would need to slide freely in a vertical channel, which is found in the central channel of the base. This channel could be created easily using a number of different materials; although frictional interference needs to be considered as this vertical motion of the arm in the base channel is what will ultimately push up on the internal rod to produce the umbrella actuation. Materials for the base of this design are a possible concern as wood might not be a good option in outside conditions but sheet metal would be difficult to produce the required design. Machined or molded plastic might work but creating a prototype might be difficult. Overall, this design could work.

Design #2

This design utilizes a rotating outer ring to actuate the umbrella. This method would quickly and safely produce the required action. One main design element to this is the table itself which mechanically speaking is quite complex. The outer ring material would need to be bent or cut from a single sheet of material. The initial design has the outer ring being made of an "L" channel of some sort. This ring rests on some ball bearings, which allows rotation. An obvious challenge is in the removal of the umbrella in a quick way. The design is based on a cable that is attached to the outer ring and passes through a pulley and through the central channel of the umbrella. The cable then exits the central umbrella channel and connects to the bottom hub to allow motion. In the event of umbrella removal, this cable would need to be detached from either the ring or the hub. This in of itself proves no major problem, but once the umbrella is put back in place, the reattachment of this cable might prove difficult. For additional safety, the internal workings of the cable and pulley are enclosed in a cap that attaches to the underside of the table. Therefore, the realignment of the cable with the pulley and attachment to the outer ring might also be difficult. A Possible redesign of the bottom cap might help if this cap had some sort of access door included to aid in the cable pulley problem. The other pieces of the umbrella and table could be made of readily available lightweight materials such as metal tubing. The legs or base of the table is not specific to the design and therefore more options are available for aesthetic creativity. This could be a decent option.

Design #3

A hydraulic assisted actuation of the hub is an improvement on any current methods available today. As designed this method allows the user to raise the umbrella by releasing the pressure in the pump, which initiates the pulley system to lift the hub. When the user pumps the lever the piston will raise and the canopy will lower. While the system is easy to actuate this current design will be expensive, heavy and may not be easy to move once finally installed. The major expense will be due to the

initial concept being designed with a hydraulic system similarly used in barbershop chairs. If we were to order one of these hydraulic systems will cost at least $130, which already positions our design at the high end of our target market price without even including the umbrella. The pulley system would require the hydraulic piston to be directly attached to the rope meaning that once it has been connected the user will have difficulty unhooking it if they desire to move the umbrella. Also, the weight will be increased by the hydraulic system at its base as well as the need for a counter weight required to compress the piston. In barber shops this weight is provided by the person sitting in the chair, our design would require the hub to provide this counter weight and anything greater than 20 pounds would make this umbrella too top heavy for functionality as well as desirability on the part of the user. As currently designed, using a barber's chair hydraulic in conjunction with a pulley, this design will be too heavy, too expensive and too difficult for the user to assemble and disassemble. Therefore, this design is not desirable.

Design #4

This design will satisfy the need of actuating the hub in a way that will keep the user out of the canopy's range of motion. The threaded screw design means that the apparatus, which actuates the hub, will stay secure making it highly unlikely to slip and close the canopy unexpectedly. It is also because of this method of actuation that the design falls short of meeting user needs and feasibility. The design will require an assembly that would be cumbersome to accomplish; the threaded pole with the canopy would need to have the table inserted from the bottom up, followed by the large screw designed actuator which would then have to be threaded onto the pole until its shaft end came in contact with the hub allowing it to settle on top of it. Once assembled in such a way the umbrella could no longer be quickly removed if necessary since the entire apparatus would now be one single unit. As far as the manufacturing process goes, it would require that we design a threaded umbrella pole and the whole screwing apparatus would almost certainly require custom manufacturing. It is due to the complicated assembly required of the user with negligible improvement over current crank actuators as well as the custom requirement for manufacturing that this design is not chosen.

Based on the preliminary physical analysis, and our desire to find a better design for our project our group has decided to come up with a redesign concept of design #3.

Revised physical analysis of the chosen design:

Design #3 - redesigned

Out of necessity to create a product with easy actuation that also minimizes necessary parts for manufacturing and user assembly, without increasing cost, we've decided to redesign the hydraulic actuation concept. As originally designed it was not the winner of our initial scoring process due to the inclusion of a pulley system and its hydraulic system being based on that of a barber shop chair. This original design made it expensive, heavy and difficult to assemble. Our new hydraulic concept now utilizes a much smaller and cheaper gas spring cylinder. The smaller cylinder will have a diameter less than that of a normal hollow umbrella pole allowing it to fit inside and provide enough force to raise the hub/canopy. Finding a gas spring with a preloaded force just great enough to lift the hub and a long enough extension to provide the needed translation will be the greatest need on our part. With a force just large enough to raise the umbrella we believe it would only require minimal force on the user's part to compress the cylinder in order to retract the umbrella. For our part we will then only need to alter an existing umbrella by creating an internal attachment to the hub that will allow it to extend down and make contact with the cylinders piston. Depending on the max extension

we can get from our piston we may also need to alter the rib attachments in order to reduce the distance required for the hub to travel. Lastly we will need to create a section where the piston head and hub extension meet that will allow the user control over the actuation.

It is because this concept best meets our design objective, user needs as well as feasibility of production that we have chosen it as the design to pursue. The final product will have all mechanical parts within the pole, allow for easy actuation and increase cost by just the price of a gas cylinder; from Internet research these will cost less than $30.

3.3.3 Final summary statement

After performing a concept scoring process and deeply analyzing each concept's physical feasibility our group has decided to pursue Design #3 – revised. The redesigned concept meets the user needs better than all the other four concepts, which allowed it to score better in the concept scoring. This design also minimizes the amount of necessary parts for manufacturing and user assembly, without increasing the cost of the design. Some of its characteristics allowed it to score better than design #1 and design #2, which scored second and third, respectively. Design #1 was a good proposal and a good idea, but materials for the base of this design were a possible concern. Additionally, there were some other concerns regarding the manufacturing process of the base. Similarly, design #2 was a decent proposal, but the reattachment of the cable that connected the outer ring and passed through a pulley and through the central channel of the umbrella was also generating manufacturing concerns and presenting some difficulty to our group. Designs #3 and #4 scored second to last and last, respectively. These two designs had a very low level of happiness because of their complex design, high cost of production, high level of complexity in the assembly process, and high weight. These characteristics and metrics placed these two designs in the last positions, which completely ruled them out of the selection process. Later on, design #3 was completely redesigned, which allowed design #3-revised to be the winner of the scoring process.

3.4 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

Once a concept was selected our group started considering the specific details of our design. Now that we have chosen a design, which consists of a gas spring cylinder internal to the pole we need to first address how to construct such a mechanism. We started looking at details like the specific pole inner diameter that needed to be considered in order to fit the smaller cylinder inside of the hollow pole. From Internet research, we have determined that most umbrella poles have 1-inch diameters and hollow tubes are readily available. With the pole dimension known we researched gas springs and found them to be easily purchased and well within the 1-inch diameter restriction. A cylinder that fits well inside of the pole and will provide enough force to raise the canopy is the most significant performance measure we must take into account. This makes the design simple while achieving our objective of easy actuation. Additionally, the spring force in the cylinder must be appropriate to lift the hub without applying too much force that it causes the canopy to expand at a dangerous speed. This will require us to determine the amount of resistance the canopy and hub provide in contrast to the preloaded spring force of our gas cylinder. This balance of forces may possibly require us to add weight within the hub if we cannot find a gas spring with a small enough pre-load. Furthermore, we have also determined that the umbrella actuator lock needs to allow 9 inches of vertical travel due to the common extension length of most gas springs as well as the amount of alteration we can make to the canopy's rib attachments without effecting too much of its support capabilities. The design will consist of umbrellas from Aldi's grocery store that are physically altered, which will make the design very affordable and easy to make. The driving factor of this design is how easy it is to manufacture, use, install, and how affordable it is.

Needs and Metrics were revised accordingly to the chosen design.

Needs Table for Umbrella Actuator (UA) – revised.

Table 9: Needs Table for UA - revised

Need Number	Need	Importance
1	UA is light weight	4
2	UA is easy to assemble	5
3	UA is easy to actuate	5
4	UA is stable	4
5	UA lowers quickly	5
6	UA has a stylish design	3
7	UA can be closed at any moment	2
8	UA is actuated by hand	4
9	UA is a safe and reliable product.	5
10	UA is affordable	3
11	UA is easy to produce	5

Metrics Table for Umbrella Actuator - revised

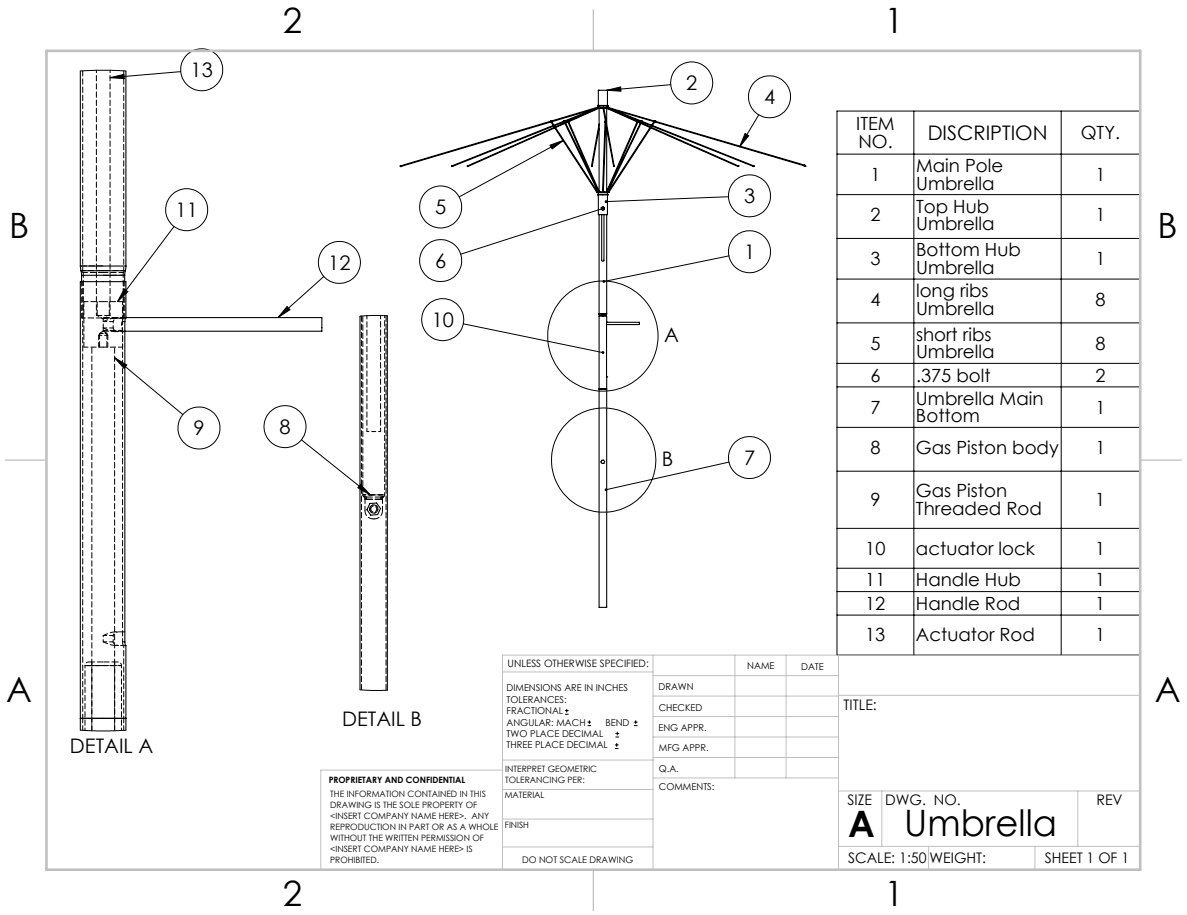
Table 10: Metrics Table for UA - revised

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1	Weight	Pounds (lb.)	10	30
2	2,5,7	Time	Seconds (s)	5	10
3	3	Force	Lb.	20	100
4	6	Aesthetics	Integer	1	5
5	8	User effort	Integer	1	5
6	9	Level of Safety	Integer	0	5
7	10	Currency	Dollars ($)	50	150
8	4	Stability	Integer	1	10
9	11	Ease of Manufacturability	Integer	1	10

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING

Figure 12: Embodiment/Assembly Drawing



4.2 PARTS LIST

Part Description	Quantity	Supplier Name	Part Number From Supplier	Price ($)	NOTES
Crane Beach Umbrella	1	Aldi's	In-store only	$12.00	Contains Main Pole Umbrella, Top Hub, Bottom Hub, Short Ribs, and the Umbrella Main Bottom
Gas Spring	1	McMaster	9416K54	$16.97	20 pounds force
Handle Hub	1	McMaster	50785k271	$3.17	-
Handle components	1	McMaster	6303k2	$4.86	-
Actuator Rod	1	Jolley Graveyard	-	Free	Part was found at the Jolley Lab 1.
Gas Spring	1	McMaster	9416k2	$19.93	15 pounds force
TOTAL	6			$56.93	

Table 11: Parts List

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

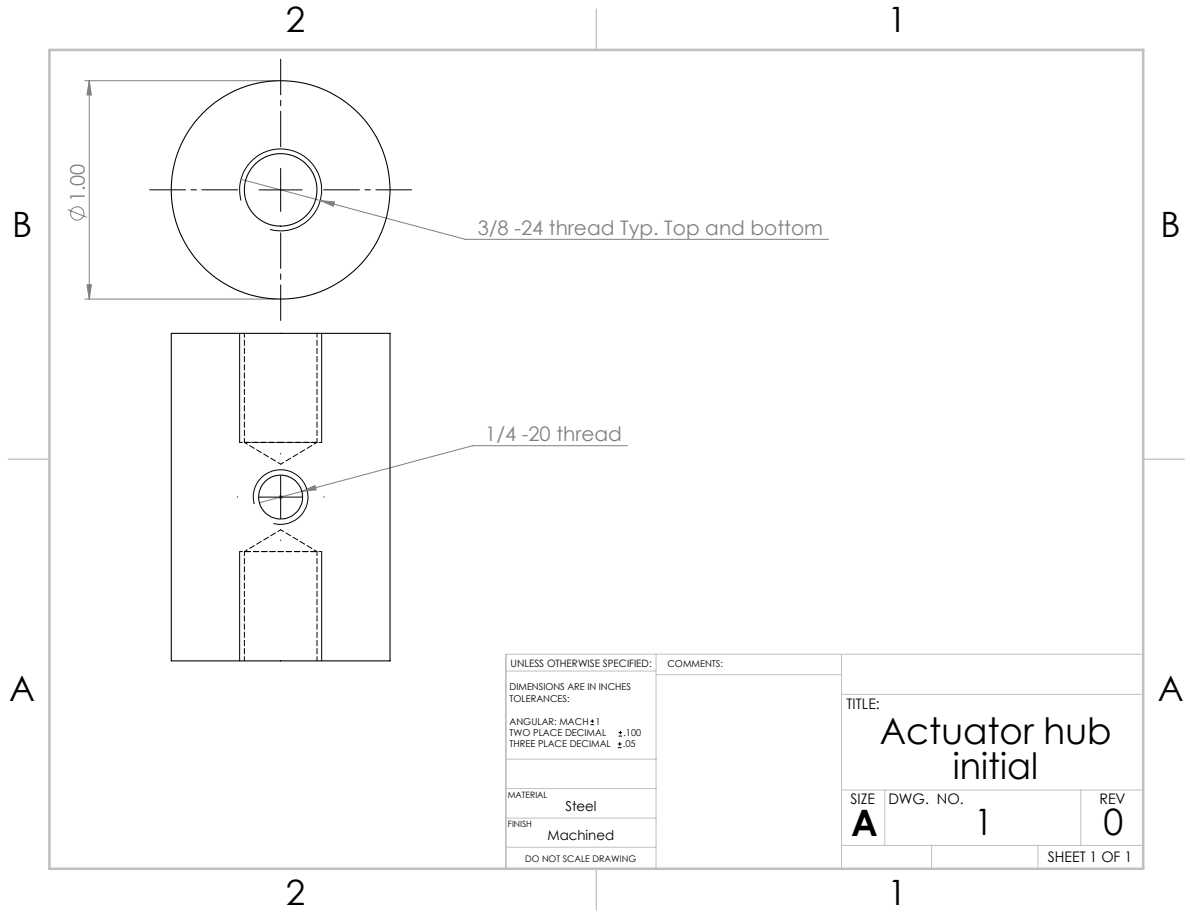


Figure 13: Drawing for Manufactured Part

NOTE: Actuator Hub – initial was the only manufactured part. All other parts were purchased or scrounged from the Jolley Machine shop.

4.4 DESCRIPTION OF THE DESIGN RATIONALE FOR THE CHOICE/SIZE/SHAPE OF EACH PART

- Beach Umbrella: The beach umbrella has already been purchased (Prof. Jakiela) and we have dimensioned other parts of this design based on it. It makes everything fit well. The umbrella pole is hollow, which will allow us to place a gas cylinder successfully inside of it. The umbrella is made of all structural components that are necessary for our design such as the pole, canopy, hub, and ribs. The initial travel distance needed to open the umbrella was about 2 ft. but after some modifications the travel distance of the hub was reduced to 9in.
- 3/8 inch Bolts: this bolts are necessary to provide support in our design. One of them is necessary to keep stationary the gas cylinder while the other bolt is necessary to connect the hub extender at the conjunction of the handle and the cylinder rod.
- Gas Piston Spring: This is one of the main components of the design. It allows the umbrella to successfully open on its own by using its preloaded force. From our research, we found a gas spring that will fit inside the hollow umbrella pole and the same time it would provide the necessary extended length of 9 inches in order to open the canopy. We have found two gas spring cylinders that would potentially work in our design. One has a longer total extension

and provides 25 lb. force, while the other one has a smaller total extension, but it still provides a force of 15 pounds. The smaller force is desired but our team will like to try both in the prototype in order to design which one is more desirable. Only by trying it on the prototype our will be able to decide which works best. See engineering analysis forward to understand decision of most appropriate gas cylinder.

- Handle components: this component provides the user with the possibility of actuating the umbrella up and down. Ease of use, aesthetics, and actuation time were some key factors that help determine that this was probably the easiest option. The components consist of a ¼ bolt adapter and the handle.

NOTE: The hub extender was acquired from the machine shop at school. We will make some changes on one end, so we can attach it to the canopy hub. On the second end, we will modify it to receive the bolt hub. Finally handle components will connect at the bolt hub. Some of these components have already been acquired. Our group only needs the two Gas cylinders, bolt hub and the handle.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

5.1.1 Signed engineering analysis contract

MEMS 411 / JME 4110
MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

ANALYSIS TASKS AGREEMENT

PROJECT:**Umbrella Actuator** NAMES: **Brian Sweeney** INSTRUCTOR:**Mark Jakiela**
Juan Mendoza
Phillip James

The following engineering analysis tasks will be performed:

Initial Analysis: Understand the forces involved in the opening of our initial design of the umbrella.

Gas Cylinder Analysis 1: After gathering all initial parts and based on the initial analysis, determine ideal force required for umbrella actuation.

Gas Cylinder Analysis 2: After revised understanding of ideal force required for umbrella actuation, an additional spring will be coupled to the gas cylinder to assist in achieving ideal force required. Analysis of the spring and spring / cylinder will be done.

Prototype Assembly Analysis: After full assembly incorporating lessons learned from the above, actuation testing will be done to fine tune the ideal force required for umbrella actuation.

The work will be divided among the group members in the following way:

Initial Analysis: Phillip James PJ
Gas Cylinder Analysis 1: Juan Mendoza JM
Gas Cylinder Analysis 2: Brian Sweeney BS
Prototype Assembly Analysis: Phillip James, Juan Mendoza, Brian Sweeney PJ JM BS

Instructor signature: Mark J. Jakiela Print instructor name: JAKIELA.

(Group members should initial near their name above.)

Figure 14: Analysis Tasks Agreement Contract

5.2 ENGINEERING ANALYSIS RESULTS

5.2.1 Motivation

The purpose of our Initial Analysis task is to help our group determine what forces are involved in the opening and closing of the umbrella. This simple initial analysis will gather the basic data needed to perform "Gas Cylinder Analysis 1" and "Gas Cylinder Analysis 2". Having all initial data will help carrying the project forward by being able to perform other analyses that are essential to our project.

The Gas Cylinder Analysis 1 will help determine how much compression force is needed to close the gas cylinder, which will close the umbrella. It is something necessary to study at this time so we can understand how to minimize the force being required of the user.

Due to the high force needed to close the cylinder a second analysis is needed. In Gas cylinder Analysis 2, in order to reduce the necessary force required for the user to compress the spring, without adding too much weight to the top half of the umbrella, we considered the use of an extension spring. The idea is that the spring will be extended while coaxially attached to the gas cylinder. With the spring initially extended, it will apply constant compressive force onto the gas cylinder rod.

After some testing from the first analysis, we determined that the required force to close the umbrella was a little high, so the extension spring was coupled to the gas cylinder, which allowed our group to perform Gas Cylinder Analysis 2. The force applied by the extension spring to the gas spring should make the compression force of the umbrella easier for the user. Based on the collected data, the group will determine if adding the extension spring to the system proves beneficial to the actuation in some way, which we predict that it will. Finally, after determining the necessary forces to actuate the umbrella, the group will move forward and be able to start testing the prototype. That's why this is something important to study at this time.

5.2.2 Summary statement of analysis done

After performing the initial analysis, the group determined that there is 12.987 lbs. acting against the piston. This is the opposing force that must be overcome to open to umbrella. The 15 lbs. extension of the gas cylinder exceeds this requirement.

Gas cylinder analysis 1 revealed that the user would probably have to exert around 6 lbs. of force down in order to close the umbrella. 6 lbs. of force was a little high from our point of view, so our group decided to perform the second analysis where an extension spring was coupled to the gas cylinder.

Gas cylinder analysis 2 proved that having an extension spring coaxially coupled to the gas cylinder made the closing motion of the umbrella easier for the end user. Based on that result, the group has decided to proceed with the redesigned process that would add the extension spring coaxially to the gas cylinder in order to assist in compression.

5.2.3 Methodology

The initial analysis was done by measuring and recording weights of the component parts as well as the force required for full umbrella actuation. A free body diagram was done to understand the forces involved in the actuation of the umbrella. These include the internal hub and rod, handle and the spring resistance force of the fully opened umbrella.

From McMaster Carr, we know that the required compression force to collapse the gas cylinder is 19 lbs. of force. Pre-testing study was performed and revealed force needed by user to close the umbrella. Also, we attached weights in increments to our gas cylinder, after attaching 14 pounds of weight; we decided that it was a reasonable amount that would make the pushing down motion easier for the user while still allowing full extension of the cylinder in a timely manner.

The gas cylinder analysis 2 was done by performing the following steps: first, it was necessary to determine whether the dimensions of the extension spring made this feasible. The spring diameter was measured. We concluded that it was large enough to fit around the gas cylinder and small enough to still be inserted within the pole of our umbrella. Second, we analyzed the spring force in order to determine if it would be strong enough to be beneficial in assisting with compression without being too strong that it prevents the gas cylinder from extending. This analysis was conducted experimentally by attaching the spring in a vertical position to a nail on a wall then attaching weights to the other end and measuring extension.

5.2.4 Results

The initial analysis allowed the group to understand the forces involved in the opening of the umbrella. This analysis was done *before* the prototype was built and showed that 12.98 lbs. of force is required for successful actuation of the umbrella.

The results of Gas Cylinder Analysis 1 showed that 19 pounds of compression was required to compress the 15lbs Gas Cylinder. Our group determined that even with the added weight of the system, the remaining force was too high for the end user. We do not want a design where the user needs to exert a total of 6 - 7 pounds for him/her to close the umbrella. This analysis was done *before* the prototype was built, and it was also tested. Testing revealed desire to make closing motion easier due to the required force to collapse it.

Results and testing of the first two analyses led the group to perform a third analysis. The result of the spring analysis gives a spring constant of 1.33 lbs./in. This shows that we can achieve a maximum compression force of 19.29 lbs. if the spring is extended the full 14.5 inches of the fully extended gas cylinder when attached to each eyelet.

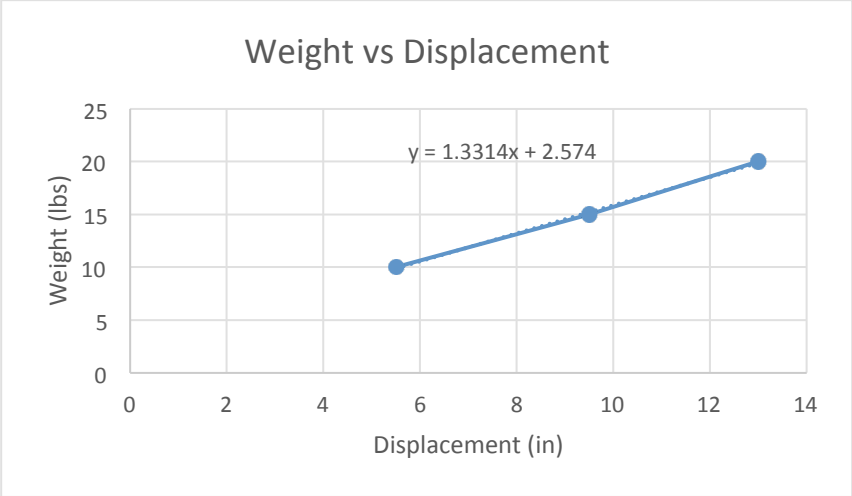


Figure 15: Weight vs. Displacement - Gas Cylinder Analysis II

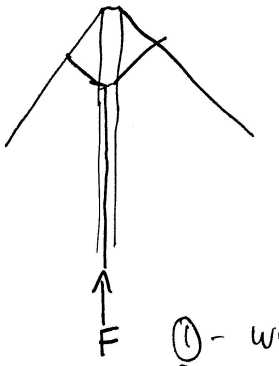
The results of Gas Cylinder Analysis 2 showed that it is much easier to compress the cylinder when the spring is couple at its ends. A total of 5 lbs. of force initiates the compression motion; 9lbs of force compresses the spring halfway, and 14 lbs. of force compresses it three-quarters of its extended length; and a total of 15 lbs. fully compressed the gas cylinder. Once the weight of the prototype was added to the top of the gas cylinder, the weight that the user needed to exert in order to collapse the umbrella was almost ideal.

5.2.5 Significance

From our engineering analysis we were able to determine that it was necessary to alter our original design to include assistance for compressing the gas spring. This is accomplished by introducing an extension spring that fits coaxially to the gas assist spring and attached to the two eyelets at each end. The additional compression force reduces the amount of force required of the user to close the umbrella. To make it even more convenient we may need to add an additional 1-5 pounds of weight for additional compression. To determine this weight we will need to assemble the prototype and do additional experiments by adding weights to the handle and judging what will be the ideal amount to provide the easiest actuation. Once the weight required is determined we will then need to incorporate a means of accomplishing this into our final design. This may require an additional weighted component or adding weight to the hub extender. The current opening time of the umbrella is ideal so we will not want to inhibit this by introducing too much weight.

Experiment.

Needed: Force required to open umbrella



→ piston will supply up force

→ forces counteracting the piston?

① - weight of internal hub and rod:
② - weight of handle:
③ - force of the "spring" of the umbrella tension:

① = 1 lb 9.8 oz = 25.8 oz

② = 9.2 oz = 9.2 oz

③ 10.8 lbs. = 172.8 oz

total = 207.8 oz = 12.9875 lbs force acting against piston

Figure 16: Initial Analysis

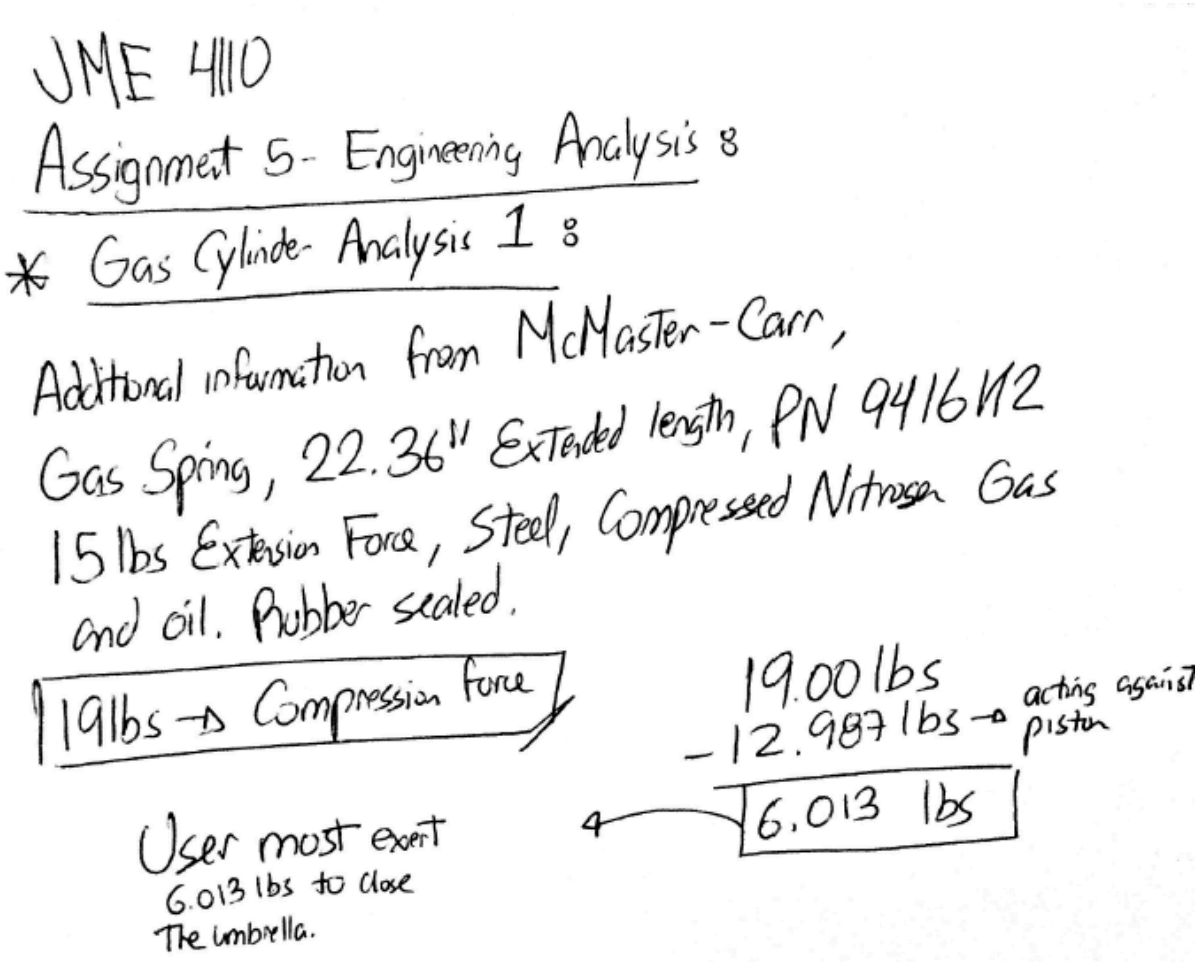


Figure 17: Gas Cylinder Analysis 2

6 RISK ASSESSMENT

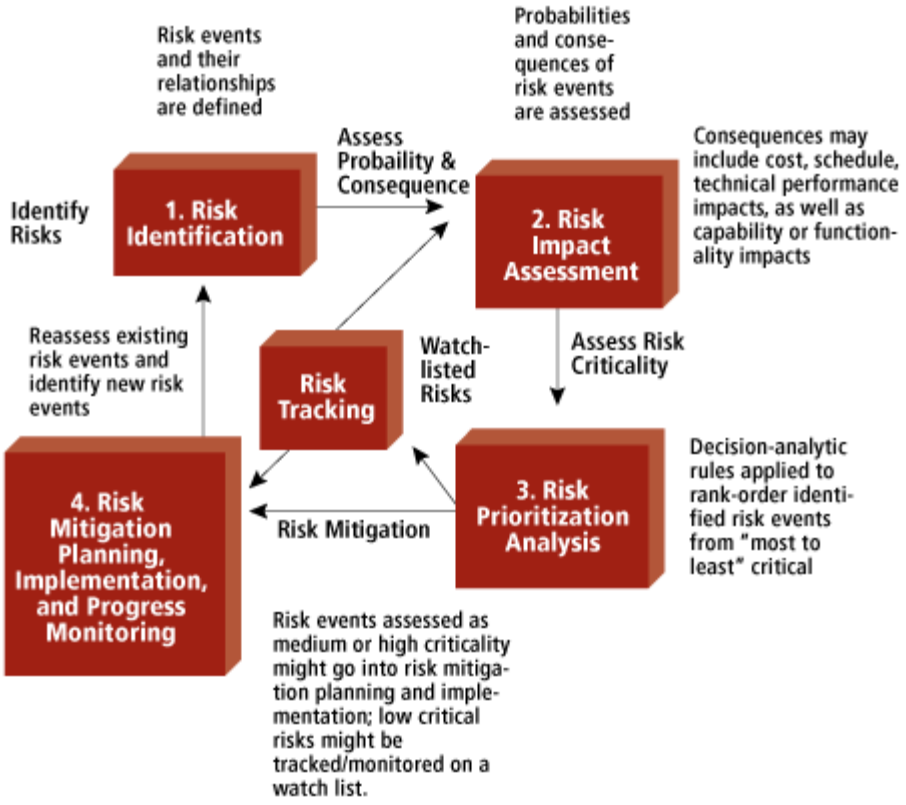


Figure 18: Risk Assessment

6.1 RISK IDENTIFICATION:

- Group member scheduling conflict
- Fabrication mistakes with material
- No access to required tools
- Miscalculated engineering analysis
- Unordered parts

6.2 RISK ANALYSIS

For the successful completion of our project we must deliver a working prototype that is fabricated within budget while meeting the semesters end deadline. Each identified risk has the potential to compromise this objective if not planned for in a way that allows for alternative solutions, if not complete avoidance.

Group member scheduling conflict: If the schedules of each group member are not made clear to the entire group than progress could be delayed.

Fabrication mistakes with material: Mistakes during fabrication could result in the need for replacement parts, which would cause delays in the schedule as well as increase cost.

No access to required tools: The fabrication will require the use of multiple tools (i.e. drills, cutting tools, bending tools) which we will need access too. If unavailable delays in the schedule could occur or at the very least quality of the prototype would be diminished.

Miscalculated engineering analysis: Miscalculations during the design will result in last minute modifications that could require new parts causing a delay in schedule, cost increase and potential deviations from proposed concept.

Unordered parts: The need for some minor unordered parts (i.e. nuts, bolts, fasteners) will affect the flow of work with only minor delays in schedule.

6.3 RISK PRIORITIZATION

To prioritize risk we have created a table to assess the likelihood of occurrence, degree of impact to the project as well as a proposed method of mitigating such an impact. While all risks cannot be planned for we feel these have the highest potential to disrupt the plan of our project.

Risk	Likelihood	Impact	Mitigation
Group member scheduling conflict	Moderate/Low	Moderate	Through clear communication all members will know the work being accomplished by the others.
Fabrication mistakes with material	Moderate	High	Proper planning and measuring. Tool work will be done by the most experienced group member for the given need.
No access to required tools	Low	Moderate	Machine shop schedule is known as well as group members possess sufficient tools for anticipated needs.
Miscalculated engineering analysis	High	Moderate	Double check all calculations and maintain flexibility in overcoming obstacles.
Unordered parts	High	Moderate/ Low	Supplies can be acquired at local hardware stores or from parts storage on campus.

Table 12: Risk Prioritization Table

7 CODES AND STANDARDS

7.1 IDENTIFICATION

Kincaid, William H. "Self-Established Ergonomic Standards." *Self-Established Workplace Ergonomic Standards*. EHS Today, 18 Nov. 2008. Web. 23 July 2016.

[ISO12100]

ISO 12100: Safety of machinery — General principles for design — Risk assessment and risk reduction**,** 2010-11-01, International Organization for Standardization, Geneva, Switzerland.

Middlesworth, Mark. "5 Proven Benefits of Ergonomics in the Workplace." *Ergonomics Plus*. N.p., 21 Mar. 2013. Web. 02 Aug. 2016.

"OSH Answers Fact Sheets." *Government of Canada, Canadian Centre for Occupational Health and Safety*. N.p., 22 July 2016. Web. 23 July 2016.

7.2 JUSTIFICATION

Ergonomic standards provide multiple benefits to an application, appliance or a workplace. In our case, the best ergonomic solution will provide the prototype with a better productivity and make it easier to operate. The lower the force that the user needs to apply, the better it is for the user. Poor ergonomics in our design would lead the umbrella users to become frustrated by the fact that they need to apply a great amount of force to close it. Ergonomics in this design shows our group's commitment to having a product that is safe to operate and that doesn't have any bad future consequences on its users. In addition to our ergonomics standards, the Canadian government and the Canadian Centre for Occupational Health and Safety have determined some "limits" of forces for vertical pushing and pulling that are recommended in order to reduce user injuries like back strain.

Basic manufacturing standards must be followed to ensure safety of product. It plays an important role regarding general principles of design as well.

7.3 DESIGN CONSTRAINTS

7.3.1 Manufacturing

Basic manufacturing standards as those stipulated in ISO 12100:2010 - Safety of machinery - General principles for design - Risk assessment and risk reduction – were followed in order to ensure that the team worked following an overall framework while following decisions that would ensure them to design a product and machine that was safe for the final user, as long as it is used for the intended purpose. In other words, basic manufacturing standards ensure that the design of the final umbrella was safe for end users.

7.3.2 Ergonomic

Ergonomic standards and a semi-working prototype of our design has lead our group to make the decision that the force required to close the umbrella should be as little as possible, four pounds or less ideally. Because of this decision, our group discarded the possibility of using the 25 lb. force gas cylinder, and decided to use the 15 lb. instead. Having a product that requires the least amount of effort from the user is one of the main goals.

7.4 SIGNIFICANCE

The constraints will influence our final prototype by adding ergonomic standards that we initially didn't think of. The initial handle has been changed by a circular handle that goes around the umbrella pole, it is supposed to make the pushing down motion more confortable and safer for the user. In addition, the 15 lb. gas cylinder has replaced the initial 25 lb. one we were considering, which will make the pushing down motion easier to the user. We have also added an extension spring that firs coaxially to the gas cylinder; it will help reduce the amount of force that the user needs to exert in order to close the umbrella. Look forward in report to the design documentation to see how some things have changed. Look at initial and final CAD models to see the differences regarding embodiment. Basic manufacturing standards are followed which follows the general principles of design. Design is safe to use.

8 WORKING PROTOTYPE

8.1 AT LEAST TWO DIGITAL PHOTOGRAPHS SHOWING THE PROTOTYPE

Figure 19: First digital photograph of prototype.

An image of the fully assembled prototype in the closed position. The doughnut handle, which is attached to the internal actuator piston, is in the bottom position of the actuator lock. While in this position the internal gas assist spring is compressed and prevented from extending until the doughnut is rotated and in line with the vertical track of the actuator lock. By rotating the doughnut into the vertical track the gas spring will be allowed to extend and the canopy will open.

Figure 20: Second digital photograph of prototype.

An image of the fully assembled prototype in the open position. The doughnut handle, which is attached to the internal actuator piston, is in the top position of the actuator lock. While in this position the internal gas assist spring is extended and providing the force required to hold the canopy open. The canopy will remain open by the extension of the gas spring as well as the doughnut being placed in the upper locked position. To close the canopy, the user will need to rotate the doughnut into the vertical track and apply some compression.

8.2 A SHORT VIDEO CLIP THAT SHOWS THE FINAL PROTOTYPE PERFORMING

https://www.youtube.com/watch?v=awW7r371e0s

8.3 AT LEAST FOUR ADDITIONAL DIGITAL PHOTOGRAPHS AND THEIR EXPLANATIONS

Image number 1

Figure 21: Doughnut handle image

The doughnut handle is the primary component the user will interact with for actuation. It is an acrylic handle that is concentric to the pole and attached to the internal actuator piston with a single bolt. The black triangle indicates where this attachment is and will guide the user when rotating the doughnut into and out of the locked positions of the actuation track.

Image number 2

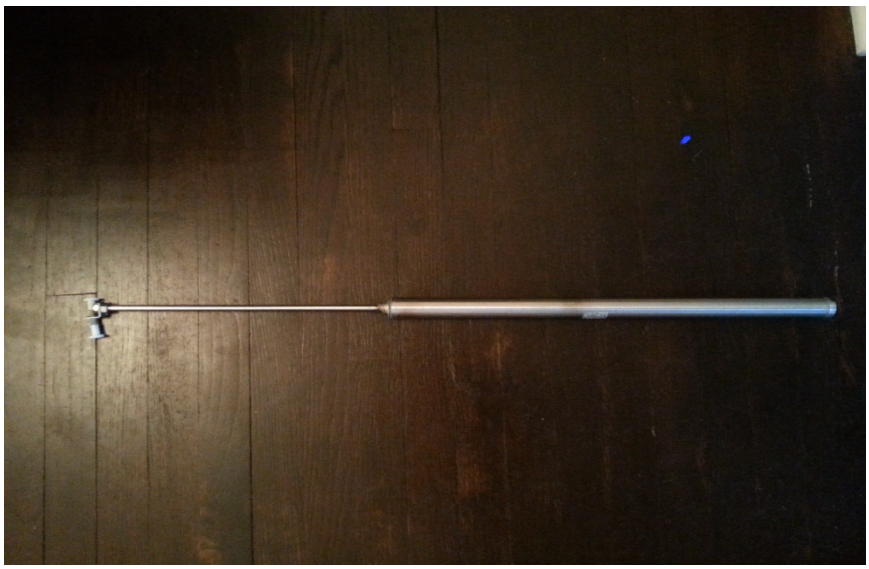


Figure 22: The Actuator Piston image

The actuator piston provides the internal connection between the gas assist cylinder and the canopy hub. This connection allows the extension of the gas spring cylinder to provide an equivalent translation to the canopy hub causing it to open and close the ribs. At the top end (skinny section) of the piston it is loosely attached to a 90-degree bracket, which in turn is attached to the canopy hub. Because the doughnut handle is attached to the body of the piston, this loose attachment allows the

piston to rotate as the user rotates the doughnut handle. The bottom end of the piston (thick section) just rests on top of the gas cylinder with no permanent attachments.

Image number 3

Figure 23: The gas assist spring image

The gas assist spring provides 15 lbs. force of extension and requires 19 lbs. force for compression. A 9-inch compression spring was attached coaxially in order to aid in compression. This combination of gas and compression springs is our primary means of actuation. The component fits within the bottom half of the pole with the actuator rod sitting on top of it. The spring will be compressed when the umbrella is locked in the closed position and will automatically extend once the doughnut handle is rotated into the vertical section of the actuator-locking track.

Image number 4

Figure 24: the acrylic grip

The whole umbrella consists of two separate poles. The bottom half houses the gas spring while all other components are attached to the top half. Here we have our connector, which has been modified to include a small grip for carrying. The grip is acrylic with a design that offers a shape contoured for fingers to rest comfortably while carrying.

9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 A set of engineering drawings that includes all CAD model files and all drawings derived from CAD models. Include units on all CAD drawings. See Appendix C for the CAD models.

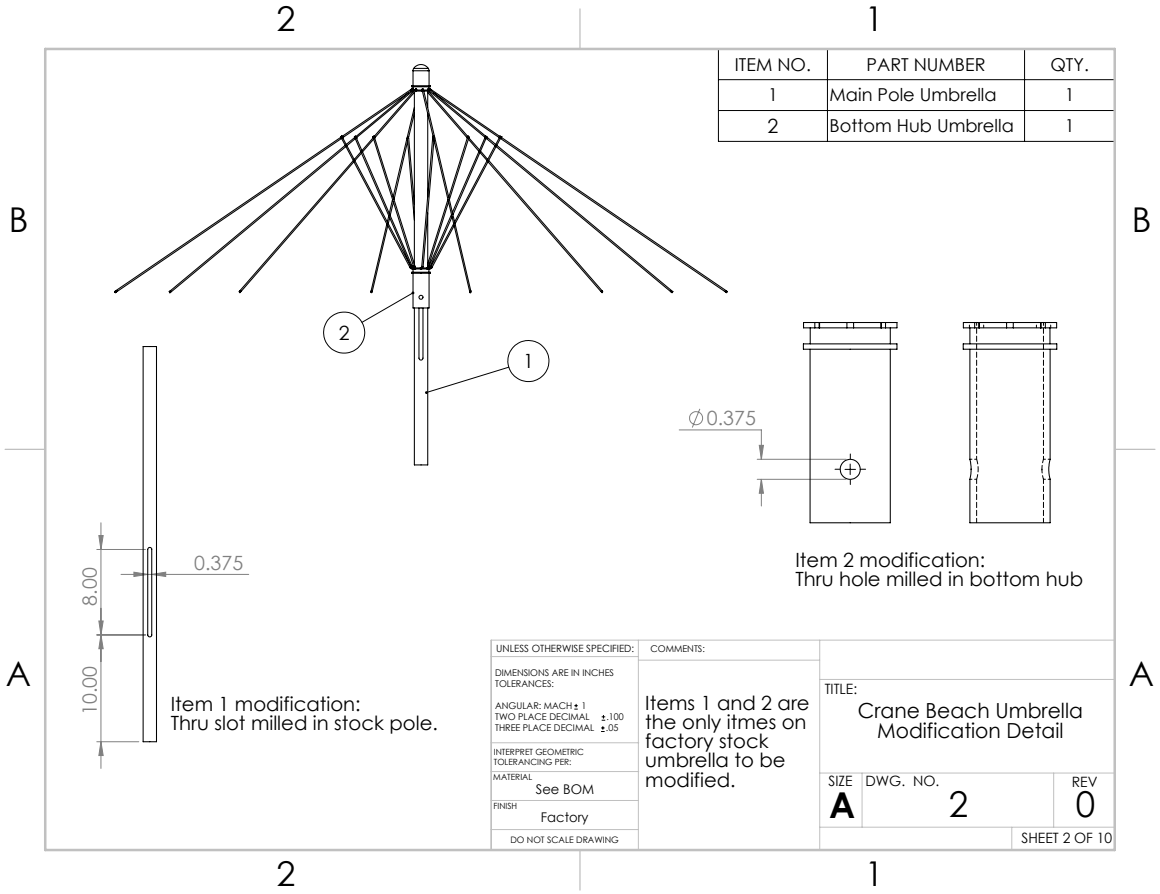
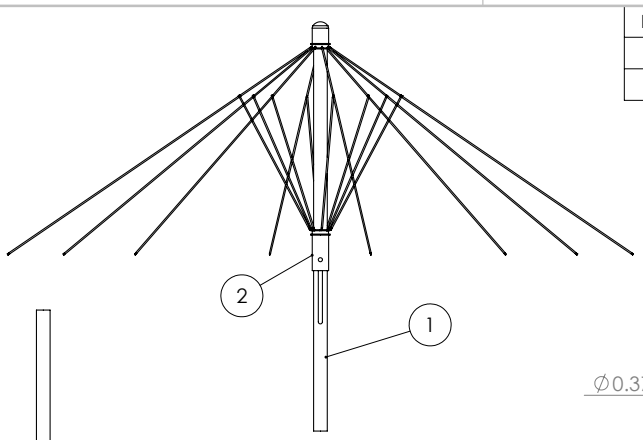
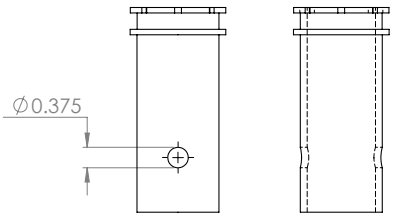


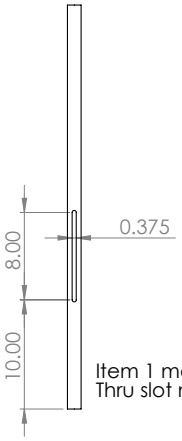
Figure 25: First Engineering Drawing

ITEM NO.	PART NUMBER	QTY.
1	Main Pole Umbrella	1
2	Bottom Hub Umbrella	1





Item 2 modification:
Thru hole milled in bottom hub



Item 1 modification:
Thru slot milled in stock pole.

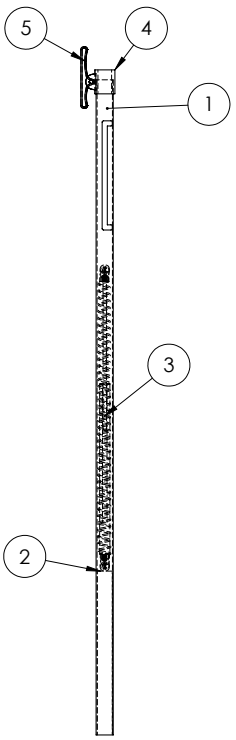
UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05 INTERPRET GEOMETRIC TOLERANCING PER: MATERIAL: See BOM FINISH: Factory DO NOT SCALE DRAWING	Items 1 and 2 are the only itmes on factory stock umbrella to be modified.

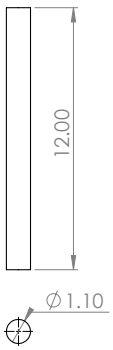
TITLE: Crane Beach Umbrella Modification Detail

SIZE	DWG. NO.	REV
A	2	0

SHEET 2 OF 10

ITEM NO.	PART NUMBER	QTY.
1	Bottom Stock Pole	1
2	base plug	1
3	Gas cylinder / spring component	1
4	pole connector	1
5	carrying handle	1





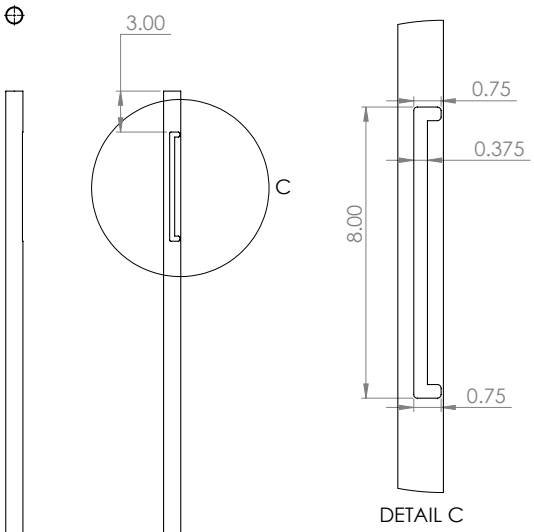
Item 2: Base Plug
Machined per print
Material: Wood

UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05 MATERIAL: See BOM FINISH: Factory DO NOT SCALE DRAWING	Further detail prints to follow showing modification detail and machined parts. Item 4 is stock item of Crane Umbrella and is not modified.

TITLE: Bottom Umbrella Pole Detail

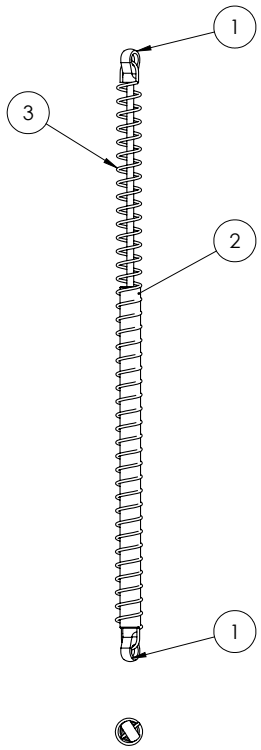
SIZE	DWG. NO.	REV
A	3	

SCALE: 1:50 WEIGHT: SHEET 3 OF 10



Stock bottom pole modification:
Milled slot as shown

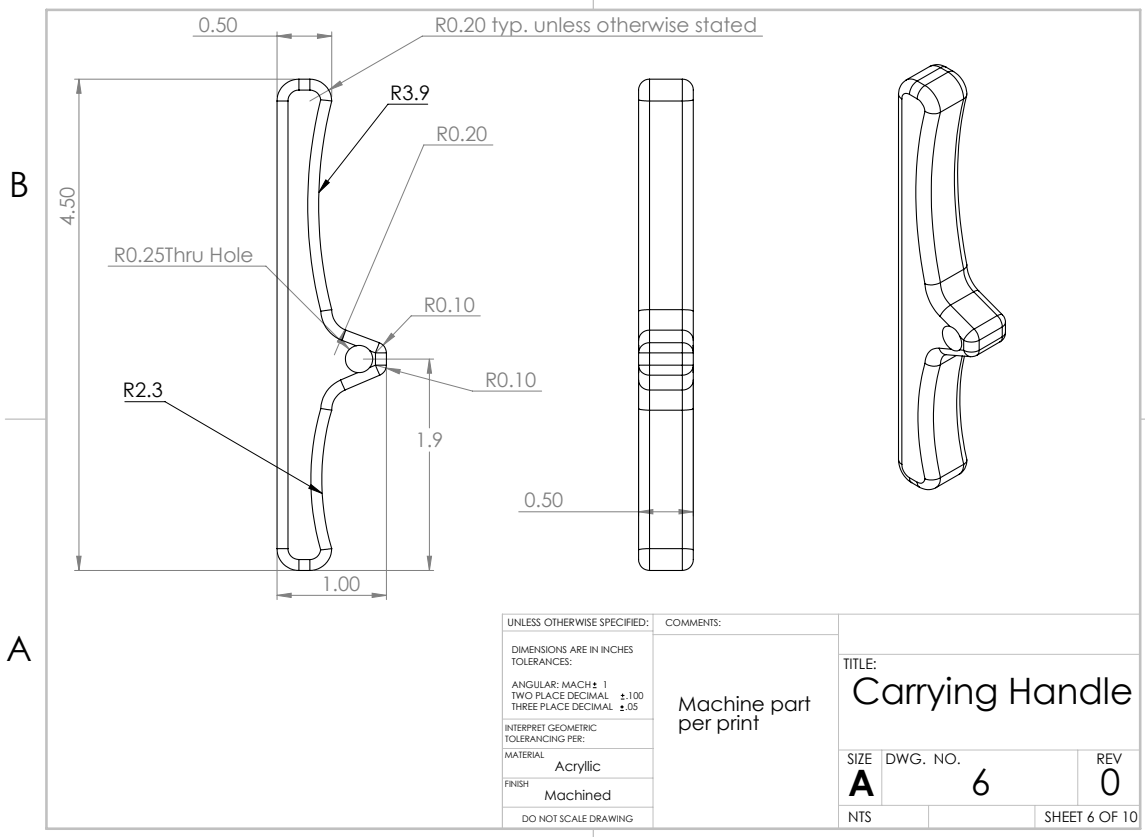
UNLESS OTHERWISE SPECIFIED:	COMMENTS:	
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05	Machine part per print	TITLE: Bottom stock pole modification
MATERIAL: Steel Stock Pole		SIZE A / DWG. NO. 4 / REV
FINISH: Factory		
DO NOT SCALE DRAWING		SCALE: 1:50 / WEIGHT: / SHEET 4 OF 10



ITEM NO.	PART NUMBER	QTY.
1	6465K610_REDUCIBLE-FORCE GAS SPRING	2
2	9416K118	1
3	spring	1

Items 1 and 2 are purchaced from McMaster Carr.
Item 3 is a found spring with 1.33 lbs/in. spring force.
Pre-stretch length is 8 inches.

UNLESS OTHERWISE SPECIFIED:	COMMENTS:	
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05		TITLE: Gas Cylinder / Spring Detail
MATERIAL: See BOM		SIZE A / DWG. NO. 5 / REV
FINISH: Factory		
DO NOT SCALE DRAWING		NTS / SHEET 5 OF 10

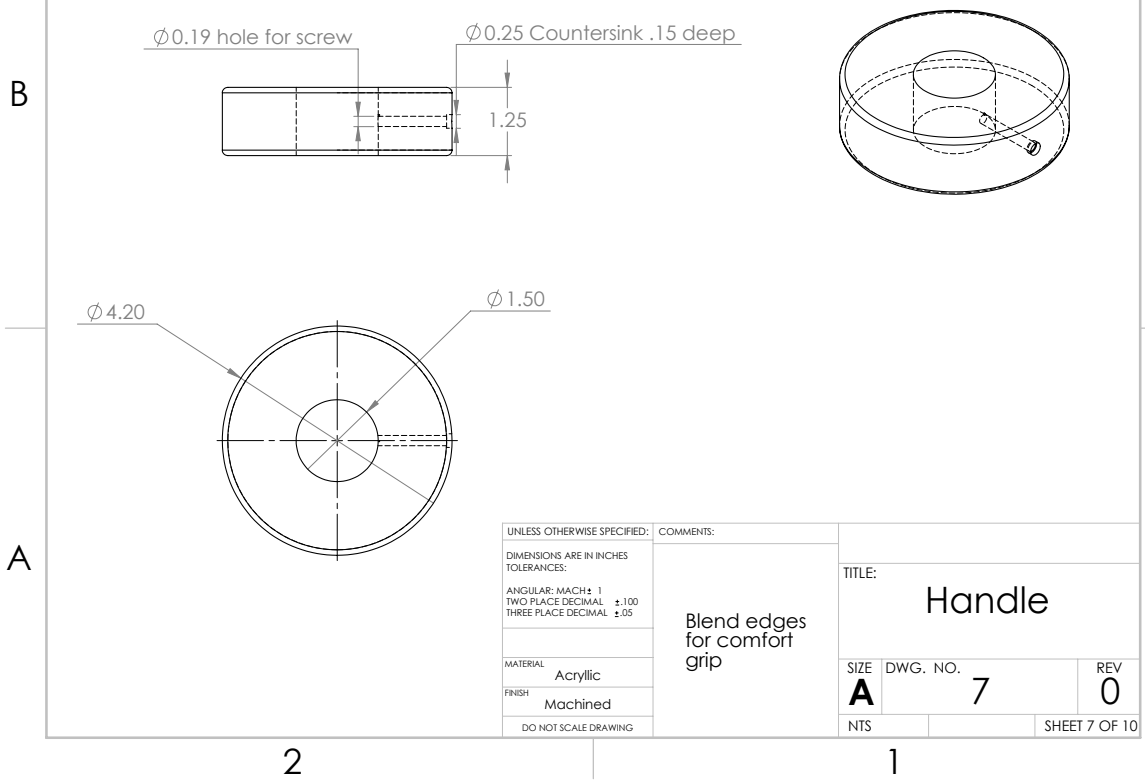


UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05	Machine part per print
INTERPRET GEOMETRIC TOLERANCING PER:	
MATERIAL: Acryllic	
FINISH: Machined	
DO NOT SCALE DRAWING	

TITLE: Carrying Handle

SIZE	DWG. NO.	REV
A	6	0

NTS | SHEET 6 OF 10

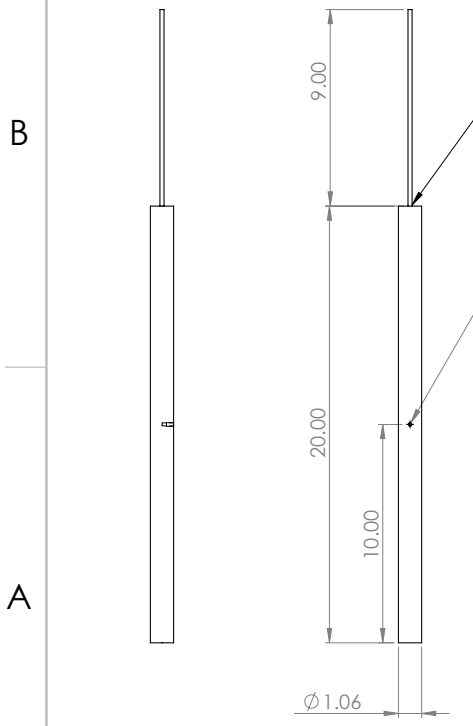


UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05	Blend edges for comfort grip
MATERIAL: Acryllic	
FINISH: Machined	
DO NOT SCALE DRAWING	

TITLE: Handle

SIZE	DWG. NO.	REV
A	7	0

NTS | SHEET 7 OF 10

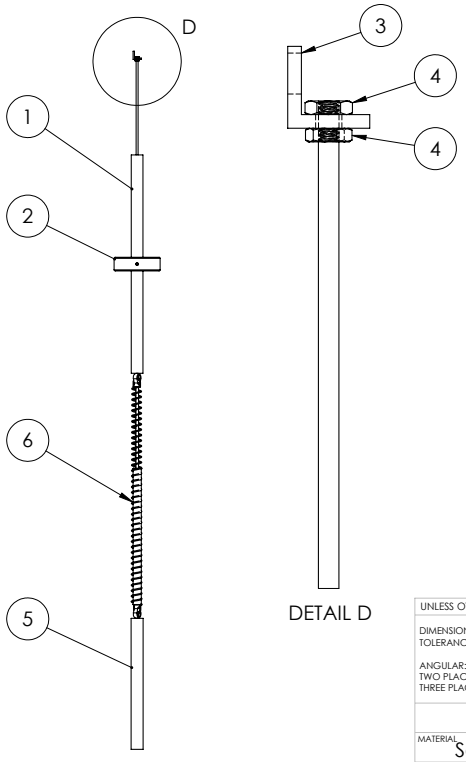


UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05	Found spring loaded piston. Welded rod as shown.
INTERPRET GEOMETRIC TOLERANCING PER:	
MATERIAL: Found Piston	
FINISH: As found	
DO NOT SCALE DRAWING	

TITLE: Found actuator piston modified

SIZE	DWG. NO.	REV
A	8	

NTS — SHEET 8 OF 10



ITEM NO.	PART NUMBER	QTY.
1	Actuator Piston	1
2	Handle Ring	1
3	L-bracket	1
4	91841A011	2
5	base plug	1
6	Gas cylinder / spring	1

UNLESS OTHERWISE SPECIFIED:	COMMENTS:
DIMENSIONS ARE IN INCHES TOLERANCES: ANGULAR: MACH ± 1 TWO PLACE DECIMAL ±.100 THREE PLACE DECIMAL ±.05	Item #4 isbought form McMaster Carr. Item #3 is a bought L-bracket from home depot, which has been modified (see folowing print)
MATERIAL: See BOM	
FINISH: Factory / Machined	
DO NOT SCALE DRAWING	

TITLE: Internal workings of Umbrella

SIZE	DWG. NO.	REV
A	9	

SHEET 9 OF 10

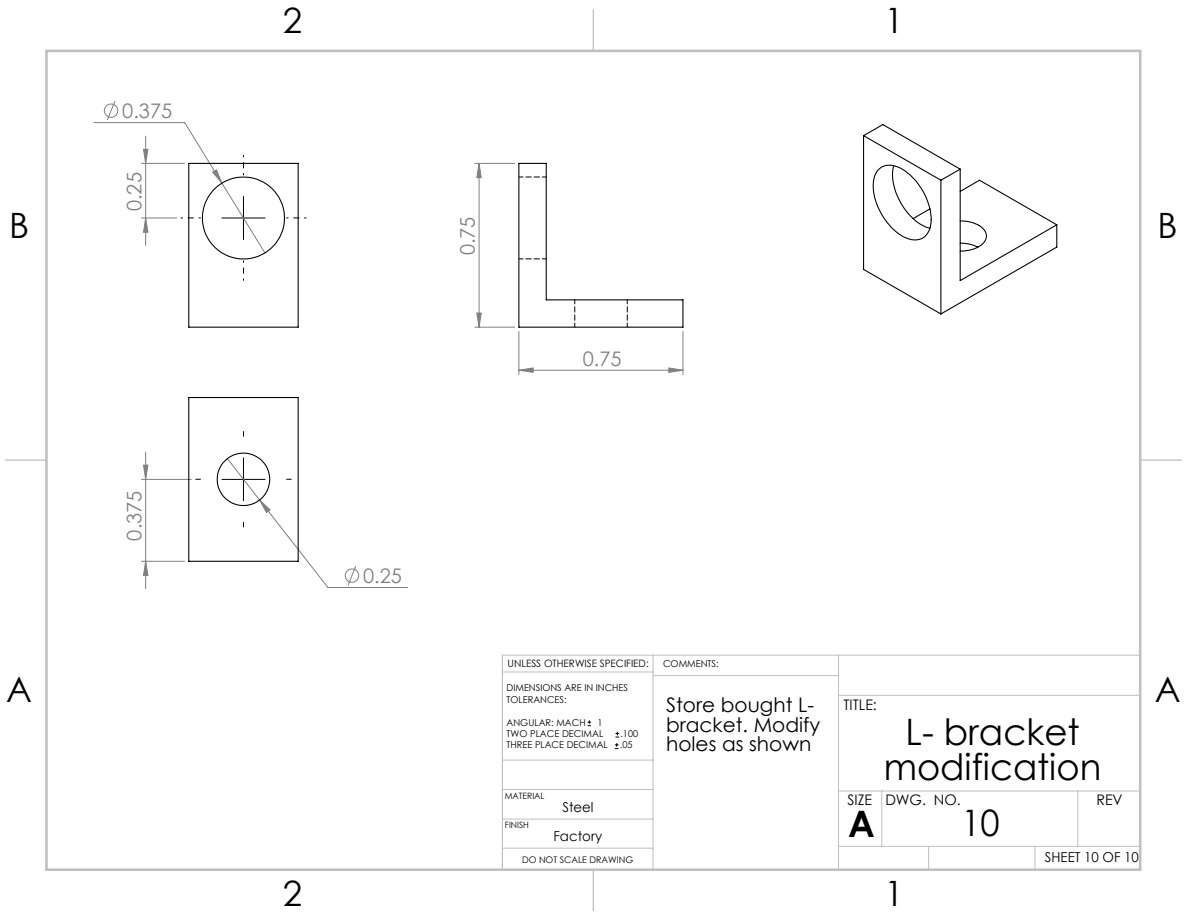


Figure 26: Tenth Engineering Drawing

9.1.2 Sourcing instructions

Part Description	Quantity	Supplier Name	Part Number From Supplier	Price ($)	NOTES
Handle Hub	1	McMaster	50785k271	$3.17	Part was purchased. Allows for user control of umbrella actuation
Gas Spring	1	McMaster	9416k2	$19.93	Part was purchased. 15 pounds force to facilitate actuation of umbrella

Eyelet end	2	McMaster	6465K610	$2.75	Part was purchased. Enables attachment of spring to gas piston
Carrying handle	1	N/A	N/A	N/A	Part was manufactured. Acrylic Machined per print to carry. Umbrella
Donut Handle	1	N/A	N/A	N/A	This part was manufactured from Acrylic. Then, acrylic Machined per print to enable user to control actuation
Actuator Piston	1	Found. Jolley Machine Shop	N/A	N/A	Dimension and weld per print to transfer vertical force to umbrella hub
Hex nut	2	McMaster	91841A011	$3.76	Part was purchased. To attach actuator piston to bottom umbrella hub
Crane beach umbrella	1	Aldi	N/A	$12.00	Part was purchased. Main component of device

L-Bracket	1	Home Depot	13542	$1.97	Part was purchased. To attach actuator piston to bottom umbrella hub
Spring	1	Found. Jolley Machine Shop	N/A	N/A	Part Dimensions per print to reduce gas piston force.
Screws	2	Home Depot	27611	$1.18	Part was purchased. To attach the handle to the actuator piston
TOTAL	14			$44.76	

Table 13: Sourcing instructions

NOTE: Please refer to Sec 8.3, images No. 1-3 for images of scrounged parts. Dimensions of all parts can be found under section 9.1.1

9.2 FINAL PRESENTATION

9.2.1 Link to the video presentation

4110 Senior Design Project - Umbrella Actuator – final presentation

https://www.youtube.com/watch?v=ClmUfVSKE4c

10 TEARDOWN

TEARDOWN TASKS AGREEMENT

PROJECT: Umbrella Act. NAMES: Brian Sweeney BS
Juan Mendoza JM
Phillip James PJ

INSTRUCTOR: Jakiela

The following teardown/cleanup tasks will be performed:

-The group has decided to keep the Umbrella actuator. Therefore, no teardown of the final project will be necessary.
-The group has returned all remaining parts to the Jolley Lab 1.

Instructor comments on completion of teardown/cleanup tasks:

Instructor signature: Mark J. Jakiela Print instructor name: JAKIELA

Date: 8/1/2016

(Group members should initial near their name above.)

Figure 27: Teardown Contract

11 APPENDIX A - PARTS LIST

Part Description	Quantity
Handle Hub	1
Gas Spring	1
Eyelet end	2
Carrying handle	1
Donut Handle	1
Actuator Piston	1
Hex nut	2
Crane beach umbrella	1
L-Bracket	1
Spring	1
Screws	2
TOTAL PARTS	14

Table 14: Final Parts List

12 APPENDIX B - BILL OF MATERIALS

Part Description	Quantity	Supplier Name	Part Number From Supplier	Price ($)	NOTES
Handle Hub	1	McMaster	50785k271	$3.17	Part was purchased. Allows for user control of umbrella actuation
Gas Spring	1	McMaster	9416k2	$19.93	Part was purchased. 15 pounds force to facilitate actuation of umbrella
Eyelet end	2	McMaster	6465K610	$2.75	Part was purchased. Enables attachment of spring to gas piston
Carrying handle	1	N/A	N/A	N/A	Part was manufactured. Acrylic Machined per print to carry. umbrella
Donut Handle	1	N/A	N/A	N/A	This part was manufactured from Acrylic. Then, acrylic Machined per print to enable user to control actuation

Actuator Piston	1	Found. Jolley Machine Shop	N/A	N/A	Dimension and weld per print to transfer vertical force to umbrella hub
Hex nut	2	McMaster	91841A011	$3.76	Part was purchased. To attach actuator piston to bottom umbrella hub
Crane beach umbrella	1	Aldi	N/A	$12.00	Part was purchased. Main component of device
L-Bracket	1	Home Depot	13542	$1.97	Part was purchased. To attach actuator piston to bottom umbrella hub
Spring	1	Found. Jolley Machine Shop	N/A	N/A	Part Dimensions per print to reduce gas piston force.
Screws	2	Home Depot	27611	$1.18	Part was purchased. To attach the handle to the actuator piston
TOTAL	14			$44.76	

Table 15: Bill of Materials

13 APPENDIX C – ADDITIONAL DOCUMENTS

The following document is a copy of the needs interview with Professor Jakiela

Possible interview questions to lead to interpreted needs

1. What types of patio umbrellas are you familiar with?

Actually, not that familiar at all. Do not own one; don't think that I have ever owned one, and not feeling like I need to get one. Have some experience using them at resorts, and my responses are informed by those experiences

2. What would you look for in a new patio umbrella? What are important features?

Light weight, easy/fast collapse. Want to be able to take it down quickly if a storm comes up. Speed is less of an issue but want it to be physically easy to erect and use. RE important features, the entire system should not seem wobbly, like it will tip over. It would be nice to be able to stabilize it while erecting/retracting, perhaps with some force from the user's foot.

3. Have you ever had to either quickly raise or lower a patio umbrella? What do you consider a quick time?

Not sure if I have ever HAD to, but I am pretty sure I had to lower quickly when a windstorm was kicking up. Lowering quickly is more important than raising quickly. Quick enough lowering time would be on the order of 5 seconds, 10 seconds would be tolerable, but don't go longer than that

4. Have you ever encountered a problem with raising or lowering the umbrella?

The torques/forces that you have to put on a hand crank (or whatever device) tend to destabilize the entire system, like it's going to tip over. Would be good if this did not happen.

5. Would you prefer that an umbrella be able to rise more quickly or close more quickly? Why?

Closing more quickly is more important, for all the reasons that I discussed above.

6. If you bought new patio furniture would you rather reuse the same patio umbrella or purchase a new one?

Given that it is an outdoor product that degrades in the elements, I would likely just get a new umbrella that matches all the other patio furniture. Should look like a matched set.

7. Do you find having to clear the table before actuating the umbrella a burden?

Again, not much first hand experience, but YES, I would think that you should not have to clear the table for the umbrella to go up or down.

8. If the actuation was beneath the table would you prefer it to be operated by foot or hand?

I think actuation by hand is safer and better. If you have to stand on one foot in order to do something, I think that you are risking some kind of injury/tripping.

9. Would it be more convenient if you could stay seated?

I don't see this as a big deal really. Erection/retraction wont be that frequent that you would want to stay seated. Deploying the umbrella would only happen once or twice per day.

10. Would you rather repair a malfunctioning umbrella or purchase a new one?

Gimme a break! Purchase a new one of course.

11. Do you prefer the conical umbrellas?

As opposed to what alternative? I am open (no pun intended) to other approaches that facilitate the actuation.

12. Do you typically find umbrellas heavy to open? Or lightweight?

Again, I don't do this a lot. My memory, however, is that a crank (driving a rack and pinion) requires fairly large forces. Would be nice if these were decreased.

13. How important is it for you that the umbrella works safely?

Really important. For a product like this, product liability is a big deal. An absolute must-have.

14 ANNOTATED BIBLIOGRAPHY

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