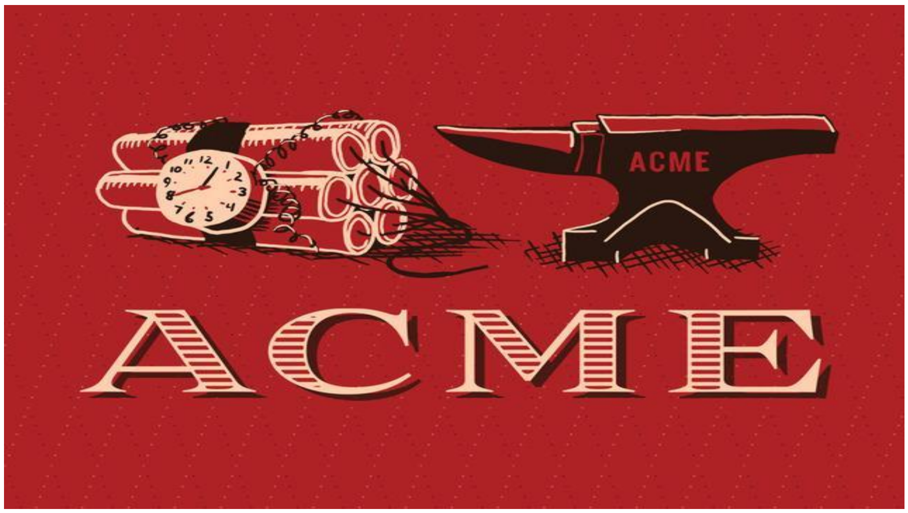
Project Proposal

Cordless Vacuum Project



Summary:

This proposal explains the motivation and constraints behind this project and pinpoints the target market. Our design utilizes a vacuum impeller technology and recycled parts of an ACME 18V Drill. Based on our tests, the internal workings of our vacuum will withstand the load of the motor. This vacuum will also accurately meet the needs of any potential customer in terms of weight, ease of use, cost, and ability.

Team 2H

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1. Introduction

1.1. Problem Statement

The purpose of this project is to develop a simple, user friendly, and aesthetically pleasing cordless, handheld vacuum for ACME Tool Company. The vacuum needs to be compatible with ACME's product family of 18V cordless drills, sanders and saws. This will sufficiently lower the cost of manufacturing and allow customers that already own ACME products of this family line some ease of use with an interchangeable battery. It will use the same motor, battery pack, and battery connector as the product platform's 18V drills. The motor and battery will not be altered. The vacuum will also collect and securely store all debris while allowing the user to empty the collection space with ease. This product will mainly target people who want a convenient means of cleaning small messes and hard to reach places without having to use a full-sized vacuum cleaner. Also, because the battery will be interchangeable with certain other ACME tools, the vacuum will stand out to owners of tools in this product family. Therefore this machine could potentially target 53 million consumers in the United States [6]. The finished product is to be launched into the market by November 15, 2015 to coincide with Christmas sales.

1.2. Background Information

The vacuum design will use the same motor and battery as the other tools in the ACME 18V cordless family. One element of vacuums that is not currently used by the other ACME tools is an impeller to create suction. The impellers spin and force air to form a flow stream directed by on the angle and curvature of their blades. Figure 1 shows resultant air vectors based on blade curve and angle. Friction with the air causes dirt and debris to be carried into the storage area. The storage space is typically wider than the entering air flow channels and this causes a decrease in pressure which slows down the air and allows particles to drop out of the flow. The air then exits the vacuum by passing through a filter which keeps dirt particles inside the vacuum. The filter also serves to protect the impeller from dirt and debris.

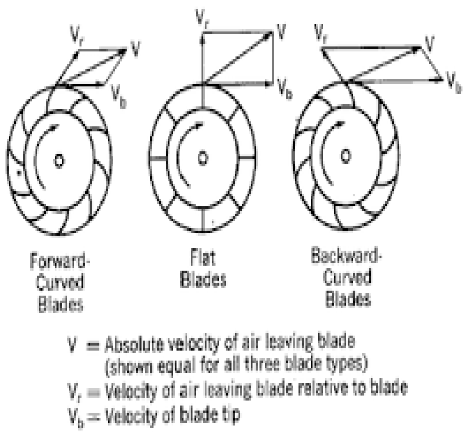


Figure 1 (left): Impellers Blade Vectors. Taken from www.globalspec.com

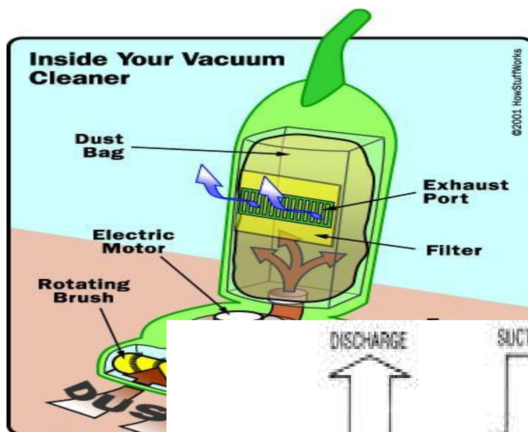


Figure 2 (right): Vacuum mechanics. Taken from www.howstuffworks.com

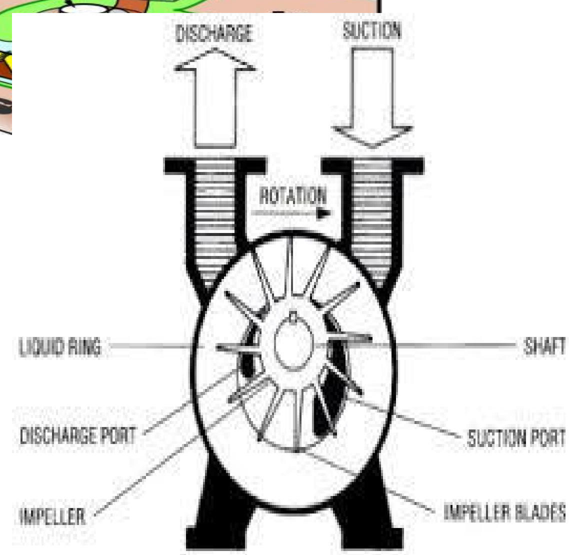


Figure 3 (right): Impeller. Taken from **www.sugartech.co**

1.3. Project Planning

The team will follow the schedule as shown in the Gantt chart in Appendix A. The major deadlines include dates by which the alpha prototype, beta 1 prototype, and beta 2 prototype will be completed, which are November 3, 2014, November 17, 2014, and December 10, 2014, respectively. Timelines have also been set for completing external searches, concept generation, system level design, detailed design, testing, refinement, pre-proposal reporting, proposal reporting and final reporting. Each of these tasks are noted in the Gantt chart.

The team will have general progress assessment meetings that will set the course for the remainder of the project on Friday of each week. At these meetings, team members will present completed work and the next set of assignments will be determined and deadlines set.

Three concept designs will be developed for consideration. Each completed vacuum design will incorporate different elements for motor, impeller, battery, collection system, and housing systems. The individual elements of these designs will then be compared to our customer needs and assessed for risk to assure that the benefits outweigh the risks. These risks include production time, ease of assembly, and manufacturing cost. The design that satisfies the most customer needs criteria and has the simplest use will be tested further. The best design specifications will be selected to become part of an encompassing final design. SolidWorks models will be produced and materials for fabrication will be selected, followed by the construction and testing of prototypes.

2. Customer Needs and Specifications

2.1. Identification of Customer Needs

A group of students was selected and interviewed to determine their collective expectations of a handheld vacuum. A table based on the interviews can be found in Appendix B. The students were of both genders, living in different kinds of apartments with varying degrees of cleanliness, and had varying frequency of cleaning their apartments. This sample represents the intended customers' needs well, due to the diversity of living environments among college students. A handheld vacuum designed to meet their needs will therefore succeed in meeting the needs of other customers. The interviews have shown an expressed interest in having a powerful vacuum, capable of cleaning very dirty spots on carpet. It was also found that a lightweight model for ease of carrying is preferable.

2.2. Design Specifications

The team used QFD (Quality Function Deployment) and AHP (Analytic Hierarchy Process) to get a general idea of the most important design criteria. Results have showed that sturdiness of design, battery life, and strong suction are included. As the AHP shows, a strong suction force was weighted the most among these criterion. The AHP can be found in Appendix C.

3. Concept Development

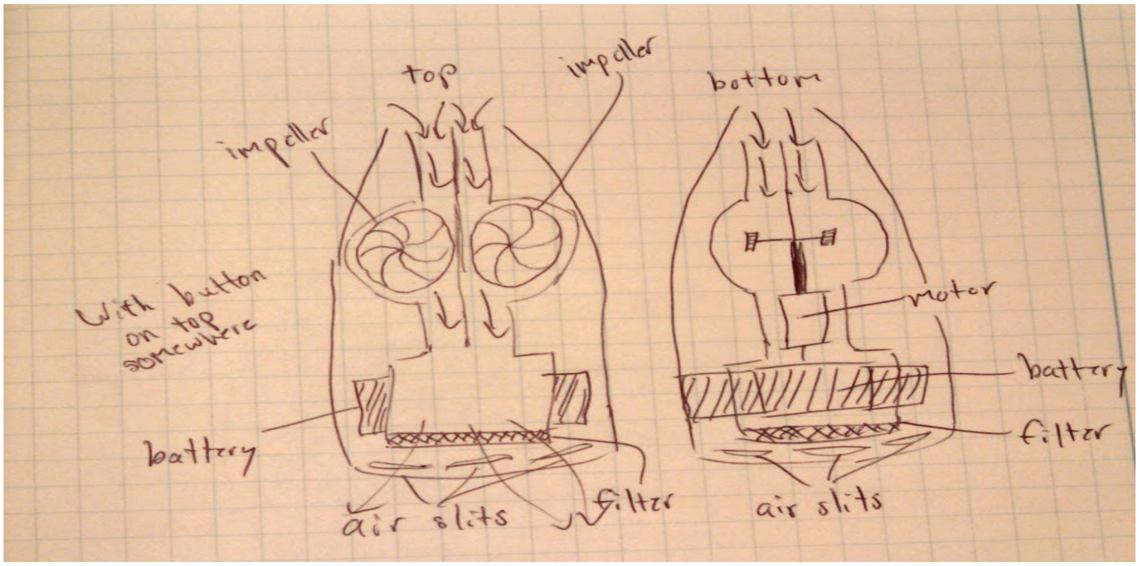
3.1. External Search

Extensive research on the needs of our target group was done. Impeller designs, air flow equations, and collection/filtration systems were also researched as were other existing handheld vacuum designs. Material costs for gears were also researched and the materials that could be used to make impellers was investigated

Problem Decomposition: There were the main problems that needed solving at this stage in the process.

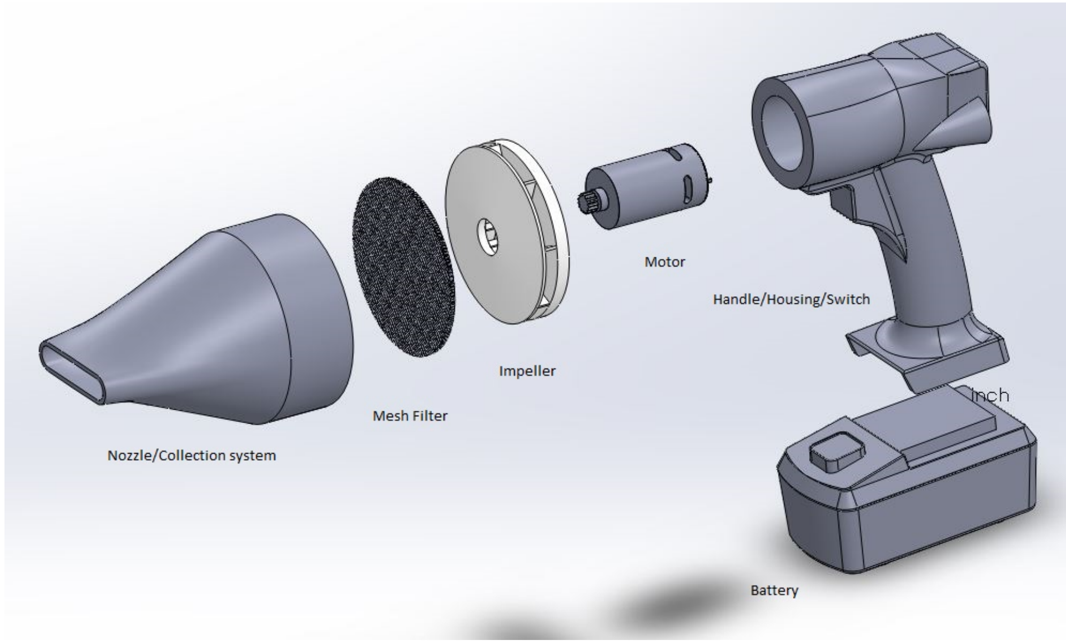
3.2. Concept Generation

-The first concept design incorporates two horizontal, curved blade impellers. Air and debris are sucked past them and funnel into a collection box located at the back of the vacuum. The motor and battery are underneath the impellers and collection box and the on button is located on a handle attached to the top of the vacuum. There was a filter at the end of the collection system and beyond that, slits in the hull for air to pass through.



-Design concept two again uses the two impeller design but they would be vertical. The motor is situated between the two impellers and behind it is the collection box and the battery. The filter is on top of the collection box and air enters the box with debris and exits through the filter in the top. The handle and button are placed on top of the vacuum.

-Design concept three, the one that the team will be developing, has the collection system is behind the nozzle. There are two lips that jut into the collection space and their length and angle will prevent material from falling back out of the vacuum no matter how is it held.After the collection system is a wire mesh filter with the impeller right behind it. The impeller will be an enclosed impeller that will suck air through a suction eye and disperse it radially so on the part of the hull ringing the impeller will be holes to allow air to escape. The back part of the vacuum will contain the motor and battery and will be similar in form to the original drill. The motor gear will be fit in the groove of the impeller to interference fit.



For Beta Prototype 1, we would use the existing housing of the drill and make the impeller as an interference fit onto the motor's gear and the collection system will be in front and will be have collection lips so that there is no back spill and the dirt collected will be taken off using a screw-off method.

5. Testing

The purpose of Beta Prototype 2 was to learn the how strong a suction force is generated and simplicity of use of the vacuum. Beta Prototype 2 was made with a storage area for the dirt and rice. Also, the intake area/nozzle was made with a smaller diameter and longer, in order to reach around corners easily. This was proven effective when we tested the design with rice by putting rice in a wall corner, as well as in the crevices of a table.

The battery was tested by running our device for 20 minutes. The battery was able to last the entirety of that time period.

The storage cylinder was made just wide enough to grip it, so the dirt storage capacity wasn't too large of an area to get in the way. When tested it, the vacuum was used to pick as much rice as possible from a bowl full. It managed to pick up 156 grams in 13 seconds. Thus, our mass flow rate was found to be 0.012kg/second. The volumetric flow rate was 0.0329 m^3/second.

6. Conclusion & Recommendations

6.1. Product Summary

Our team was able to design and manufacture an 18V, cordless, handheld vacuum cleaner to become a part of the ACME tool family. The market need was met for consumers in need of a simple, effective means of collecting debris. For existing ACME customers, this vacuum shares the same rechargeable battery and motor as ACME saws, sanders, drills, and other 18V tools, which significantly eases use and cost.

Key features of the product include, but is not limited to, a powerful, yet lightweight vacuum cleaner with a simple, easy way of emptying the collection of dirt and other debris. A closed centrifugal impeller with ample exhaust provides a strong suction for efficiency. A mesh between the nozzle and mechanical section of the device allows for all matter to be collected into a separate compartment for storage until emptying. The vacuum also employs a trigger function, rather that an on/off switch to save battery power for maximum usage before recharging.

Compared to the competition, our product is inexpensive and very efficient. We predict that our vacuum will do very well in the current and future markets.

6.2. Improvements

There are areas of the product that could be improved. First, the collection system has room for development; during one test, some of the debris that was collected came out of the nozzle instead of continuing into the collection system. We have been able to identify and attribute this happening to the dynamics of the system; when the power is turned off, the device is pointed downward, and due to gravity effects, when there is no more suction, some debris is allowed to fall out.

In addition, the aesthetics of our design should be improved. There are some sharp edges and inconsistent areas, as well as a bland coloring. Should this product reach stores, ACME and its marketing department may decide the best "look."

References

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3)Fan or Impeller Types & Performance
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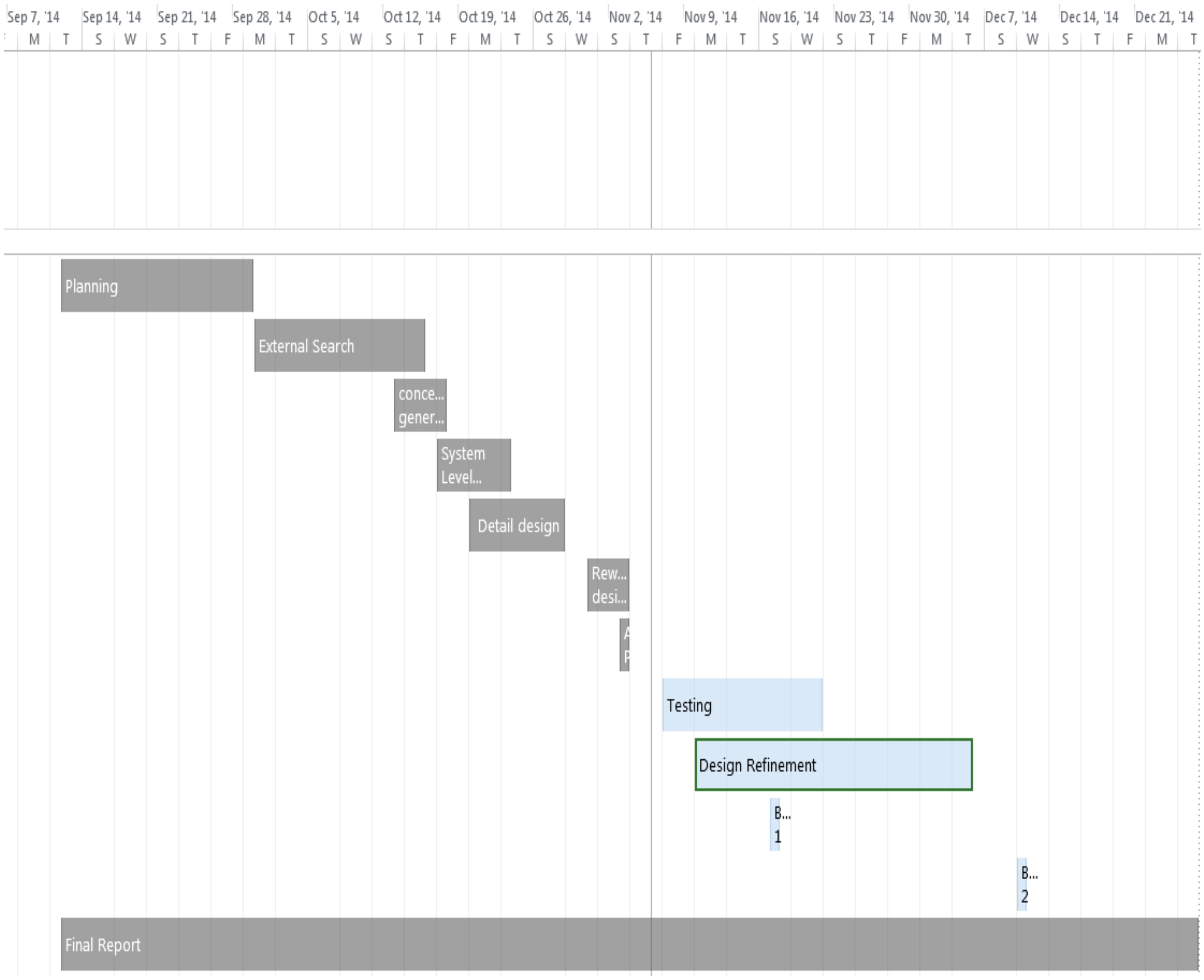
Appendices

Appendix A

Gantt Chart



Appendix B

Customer Statement	Needs Statement
Easy to handle- easy disposal of garbage, easy to hold	The vacuum has a simple mechanism to store the dirt
It should be cheap	The vacuum will not cost too much

It shouldn't be too heavy	The vacuum will be easy to hold for 10-20 minutes and work with it
It should look good	The vacuum will look aesthetically pleasing
It should be small enough to fit under the table	The vacuum will be compact
It should have a removable battery	The vacuum will have a detachable battery
It should have a long lifetime	The vacuum would be made sturdy to last a long time
It should have strong battery life	The vacuum will have a battery life of more than 20-30mins
It should be powerful in cleaning big messes	The vacuum will have powerful suction force
It should let us know when the trash bag is full should let us know	The vacuum will have an indication of when to throw the trash out
It shouldn't short circuit	The vacuum battery is protected from accidental short circuiting
It should be easy to repair if necessary	The vacuum should have easily replaceable parts if one of the parts breaks down

QFD

Needs	**Metrics**	Time to install	Power (kW)	Cost to install($)	Sound intensity (dB)	Volume (m^3)	Energy Efiiciency	Weight (kg)	Aesthitically Pleasing
Simplicity of Design		x		x			x		
Not too costly						x			
Not too heavy			x					x	
Compactness		x		x		x		x	x
Detachable Battery		x							
Sturdiness of Design		x			x	x			
Battery Life			x				x		
Strong Suction Force			x		x		x		
Trash Bag indicator			x	x					
Protection from Short Circuiting		x		x					
Easily replacable		x		x				x	
Not so noisy					x		x		

Appendix C

AHP

	Simplicity of Design	*Not too costly*	*Not too heavy*	*Compact-ness*	*Detachable Battery*	*Sturdiness of Design*	*Battery Life*	*Strong Suction Force*	*Trash Bag indicator*	*Protection from Short Circuiting*	*Easily replacable*	*Not so noisy*	***TOTAL***	***Weight***
Simplicity of Design	1	3	1	0.33	5	1	0.33	0.2	5	0.33	5	3	25.19	0.09241
Not too costly	0.33	1	0.33	0.33	0.5	0.2	0.33	0.2	5	0.5	3	5	16.72	0.061338
Not too heavy	1	3	1	0.2	3	0.2	0.2	0.2	5	0.33	3	0.33	17.46	0.064052
Compactness	3	3	5	1	3	0.33	0.2	0.2	3	0.33	3	3	25.06	0.091933
Detachable Battery	0.2	2	0.33	0.33	1	0.33	0.2	0.2	3	0.33	5	0.2	13.12	0.048131
Sturdiness of Design	1	5	5	3	3	1	3	1	5	3	3	5	38	0.139403
Battery Life	3	3	5	5	5	0.33	1	1	3	5	3	3	37.33	0.136946
Strong Suction Force	5	5	5	5	5	1	1	1	5	3	3	5	44	0.161415
Trash Bag indicator	0.2	0.2	0.2	0.33	0.33	0.2	0.33	0.2	1	0.5	0.33	0.33	4.15	0.015224
Protection from Short Circuiting	3	2	3	3	3	0.33	0.2	0.33	2	1	3	5	25.86	0.094868
Easily replacable	0.2	0.33	0.33	0.33	0.2	0.33	0.33	0.33	3	0.33	1	0.2	6.91	0.025349
Not so noisy	0.33	0.2	3	0.33	5	0.2	0.33	0.2	3	0.2	5	1	18.79	0.068931
												SUM	272.59	1

Appendix E

Part	Amount	cost per part	Vendor	Assumption
Epoxy	5	$3.54	Alliedelec	one of them can be used for 5 different units
velcro strips	2	$3.49	walmart	
ABS plastic (material and molding)	100,000	$3.09	custompartnet	aprroximately 1 lb of plastc used
Self tapping screws	50	$0.51	mcmaster	
Labor cost	3	$1.80	semi skilled labo	$18 an hour
motor		$8	drill master	
battery		$6	drill master	
	TOTAL	$26.43		
	COST FOR 100,000	$2,643,000		