

Group R

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### Progress Report One

The past four weeks have been a stage of preliminary research and development for the team. The purpose of this stage was to explore the basic components of the Advanced Energy Vehicle (AEV) project. The team conducted this research through a series of labs covering the topics of basic coding to the initial individual designs of the AEV. In the first portion of the labs, the team investigated the Arduino Nano board, the controller for the AEV, and how it operated. Understanding the controller was crucial to the team's success because it is the "brain" of the entire vehicle. In order to learn more about the Arduino Nano board, the members of the team programmed the board to perform tasks similar to those that the final AEV will perform. These initial labs also included learning about the reflective external sensors that will allow the AEV to be programmed to run specific distances. The team created Arduino codes using the specific function calls related to sensors so that the AEV's travel was reliant on distance rather than time. After this, the team used a software which was a combination of MATLAB and Arduino to examine the energy use during travel. The Data Analysis Tool was used to record data and create plots that showed Power v. Time and Distance v. Time. These plots would be valuable information to the team because energy is a very important cost factor within this project. The labs also pushed towards the initial design and team decision making process. Each member created their own individual design and later, the team all came together to discuss these designs

through concept screening and scoring. These initial designs would lead to the first model of the AEV.

In the first lab, the team learned how to use Arduino, the program to be used on the AEV, and its syntax. The first of two tasks to be completed was a scenario which contained numerous situations that the team may encounter while programming the AEV. These situations included accelerating the motors, braking the motors, reversing the direction of the motors, and running the motors simultaneously at different speeds and polarity (see attached: Code 1:1). While conducting this lab, observations were made about the performance of the Arduino and its components. For instance, the motors do not begin spinning immediately after the code starts to run. Another observation is that the brake command only stops the motors from running and this does not guarantee that the AEV will stop as well. An error that could have occurred during the procedure would have happened while the Arduino was running the program. Many different commands were happening simultaneously, and it would have been difficult to notice if the Arduino didn't execute a command.

In the second lab, research was conducted on the reflectance sensors. The sensors are used to measure the distance traveled by the AEV in marks, which is approximately 0.4875 inches. The first step in this procedure was to correctly attach the sensors to the arm of the AEV (Image 1).

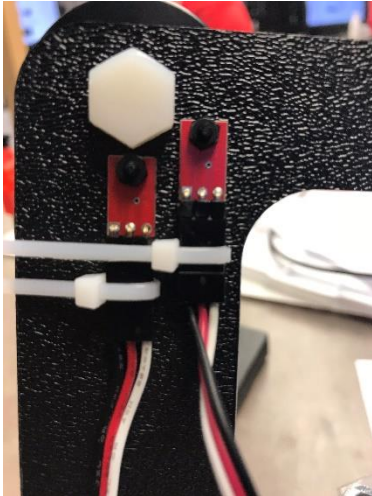
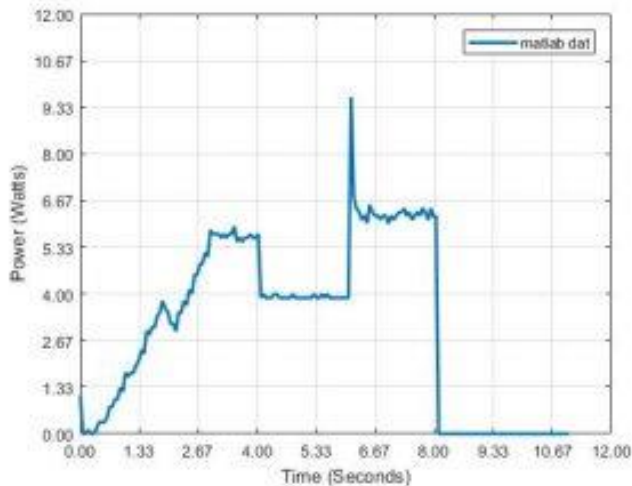


Image 1: Sensors attached to the AEV arm

After this was done, the next step was to create a code for the Aduino using the syntax for the reflective sensors. These commands use distance as the variable rather than time (see attached: Code 1:2). Similarly, to the first lab, the brake command is not going to immediately stop the AEV even after going the specified distance. The vehicle will go the programmed distance and then cut the motors. And because it is already moving, it will continue to move after the motors stop.

After investigating the reflective sensors, the team researched the Data Analysis Tool. This is a program that combines Arduino and MATlab to interpret data imported from the Arduino board after running a program. The program was used to analyze the energy used by the AEV after a run on the track in terms of distance and time. The team created a program in Arduino that accelerated and decelerated the motors so that their energy usage could be studied (see attached: Code 2:1). The plot for distance versus time can be seen in Graph 1 (see attached: Graph 2)



Graph 1: Energy v. Time of Code 2:1

As seen in the graph, the upward slanted lines represent the acceleration commands and the straight lines represent when the motors are running at a constant speed. The spike in energy usage around six seconds is when the reverse command is used. Referring to the code, after six seconds of other commands, the program reads “reverse(4);” which is evident in the plot. After running this scenario, the Data Analysis Tool would prove to be an important tool in measuring the energy used by the AEV during its travels.

The next stage of labs had the team members engage in creative design thinking. The purpose of these labs was to create designs that could potentially be incorporated into the final design. Each team member created a design individually and brought it to the team to be discussed. Design A (Figure 1) is a design whose main body is meant to resemble that of a fish. A thin front with a curved, streamline body would aid the AEV in aerodynamics and safety (as it houses all of the components inside of a 3D printed shell). But because of its wider back, this design would not be aerodynamic in both directions of travel. Design B (Figure 2) was modeled after the shape of a football and how it cuts through the air during travel. The primary feature of this design is the 3D printed shell that encases every component of the AEV. The motors are

placed on either side of the body, facing in opposite directions with the intention of keeping the motor power equivalent when traveling backwards or forwards. Both designs required 3D printing, which would be costly to our solution to the task.

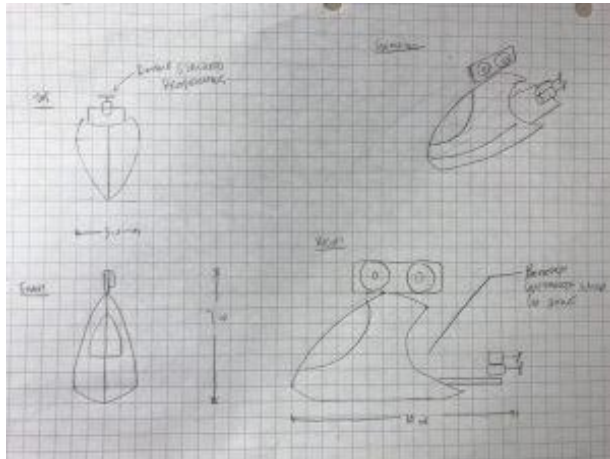


Figure 1: Design A

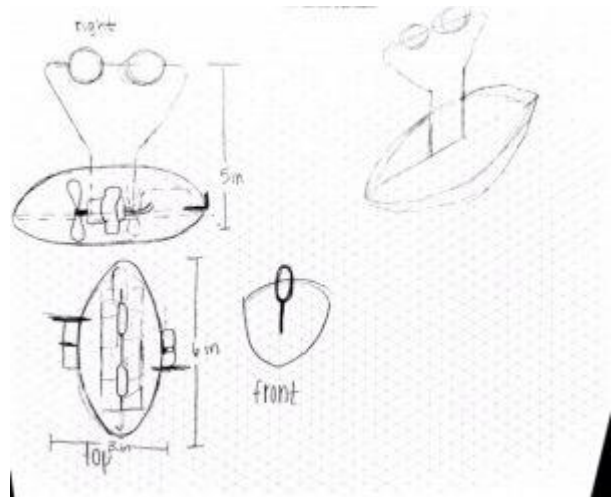


Figure 2: Design B

The main feature of Design C (Figure 3) is its structure. The components important to the AEV would be stored inside of the boat-like body. This design is meant to be sturdy and durable. The design is minimalistic in the parts used, however, those parts that are used are quite heavy. The lack of parts used would bring down the cost of materials, but the mass would increase the amount of energy needed to get the vehicle from one point to another, ultimately increasing cost as well. Unlike Design C, Design D (Figure 4) was designed with mass in mind. The body of this design is the plastic cross shape provided in the AEV kit. It's slim, flat profile along with small mass makes for a quicker trip while using a fraction of the energy of other designs. After all the designs were brought to a team meeting, the members discussed the individual designs and created the first draft to a team concept sketch (Figure 5). This design featured one of the plastic rectangles attached flush to the arm and another plastic rectangle perpendicular to it which held

the motors, acting as wings. One of the main factors of design for this concept was the cost of the parts used. Therefore, the model contains only a few pieces provided in the AEU kit. The lack of extraneous parts will also lead to a lesser mass.

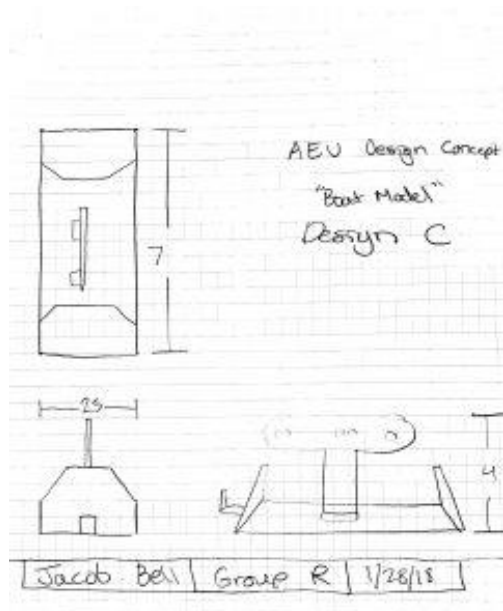


Figure 3: Design C

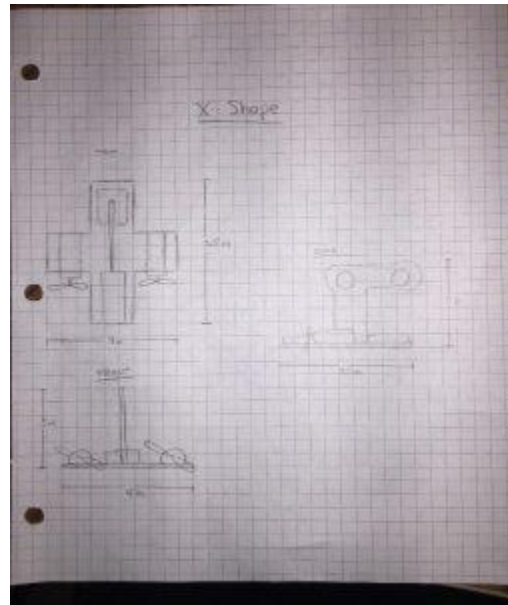


Figure 4: Design D

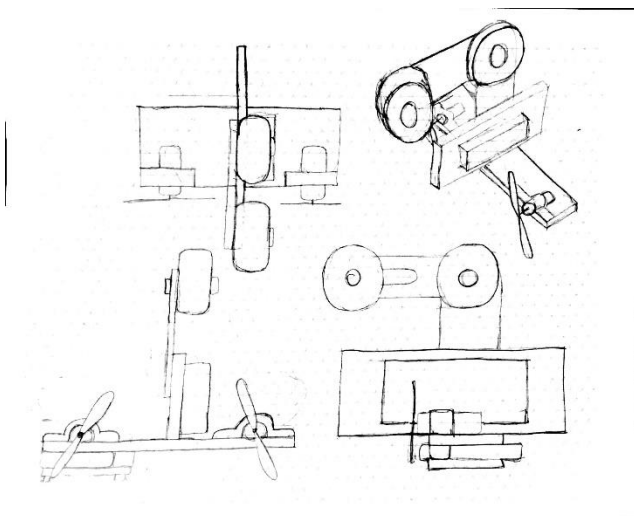


Figure 5: Team Concept Sketch

The next step in the engineering design process was to create design screening and design scoring matrices. A screening matrix is used to quickly analyze the properties of the AEV by using plus signs and minus signs. The properties scored in both matrices are stability, durability, aerodynamics, mass, and cost. Stability is the measure of how balanced the vehicle is while on the track and durability is the model's ability to be taken apart and put back together without easily breaking. The aerodynamics category is how well a model cuts through the air during its travel. As for cost and mass, these factors were graded based on how much they benefited the solution. For instance, if a model has a plus sign in the cost row, it means that the cost is low and that that is an appealing feature for that specific model. Table 1 (shown below) is the concept screening matrix for the four individual designs.

Success Criteria	Reference	Design A	Design B	Design C	Design D
stability	0	+	+	+	-
durability	0	-	+	+	+
aerodynamic	0	-	+	+	-
mass	0	+	+	-	+
cost	0	+	-	-	+
sum +'s	0	3	4	3	3
Sum 0's	5	0	0	0	0
Sum -'s	0	2	1	2	2
Net score	0	1	3	1	1
Continue?	combine	combine	combine	no	yes

Table 1: Concept Screening Matrix for designs A, B, C, and D

Similar to the screening matrix, a scoring matrix was then applied to these designs as well. A scoring matrix assesses the designs by giving each property a weighted score from one to five (five being the best). The matrix created by the team is shown below as Table 2.

		REFERENCE		DESIGN A		DESIGN B		DEISGN C		DESIGN D	
Success Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
stability	20%	3	0.6	3	0.6	4	0.8	3	0.6	2	0.4
durability	15%	3	0.45	2	0.3	5	0.75	4	0.6	3	0.45
aerodynamic	10%	2	0.2	2	0.2	5	0.5	3	0.3	2	0.2
mass	30%	3	0.9	4	1.2	2	0.6	1	0.3	4	1.2
cost	25%	3	0.75	4	1	1	0.25	1	0.25	4	1
Total Score			2.9		3.3		2.9		2.05		3.25
Continue?		no		combine		no		no		yes	

Table 2: Concept Scoring Matrix  
for designs A, B, C, and D

The team decided that the most important feature of the AEV was its mass, so it was given an overall weight of 30%. Aerodynamic was deemed the least important of the scored features so it was given a weight of 10%. Based on their scores from the matrix, elements from both Design A and Design D. Both the screening and scoring process are fundamental to the engineering design process because they provide a numerical means of decision making.

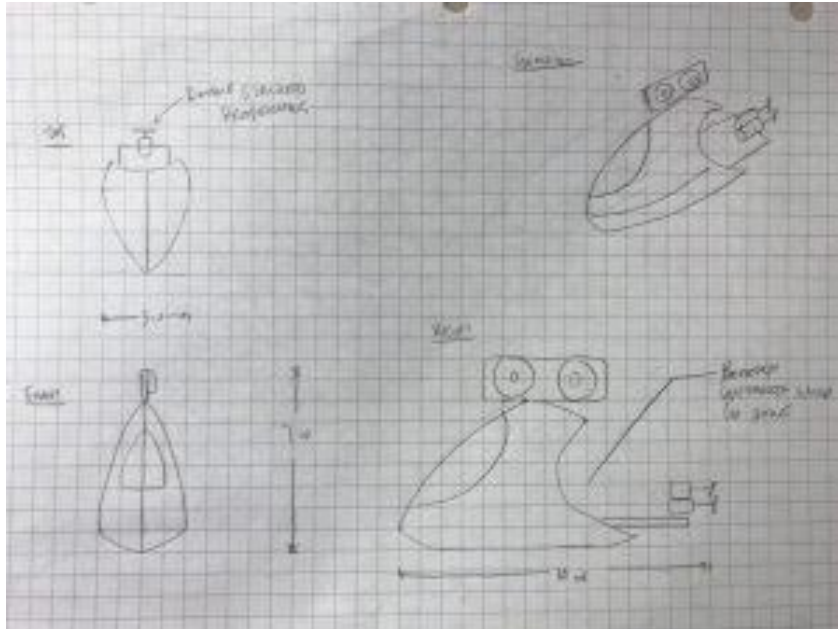
In the upcoming labs, the team will run advanced testing that will provide more in-depth information about different components of the AEV. As the team looks to the future, there are two main points of focus: the stability of the vehicle and its efficiency. These two areas will be studied in the motor configuration lab and the coasting versus power braking lab. The motor configuration lab will allow the team to run tests with various motor positions to collect useful data relating to the energy it uses. After analyzing this data, our group will be able to choose a configuration that the AEV will utilize. The data collected will be interpreted using the Data Analysis Tool. Afterwards, the coasting versus power braking lab will be conducted. In this research lab, testing the different properties of coasting and power breaking will be crucial to the success of the task. A simple Arduino code will be created and used to test both methods. The

lab will use the AEV, the LI-PO battery, the Arduino nano board, and the test track. The team will collect data focusing on the time and energy used to stop the vehicle. Through the advanced research and development, the team plans to test different components of the AEV. By testing these various components, the team will find the strongest methods to use moving forward with the design and structure of our efficiency. The main goal of these labs will be to understand what makes the most energy efficient AEV model. With energy usage as the thesis of the research, the team will be able to create a vehicle more than capable of completing the task at hand, and do so in efficient, inexpensive, and most importantly, safe manner.

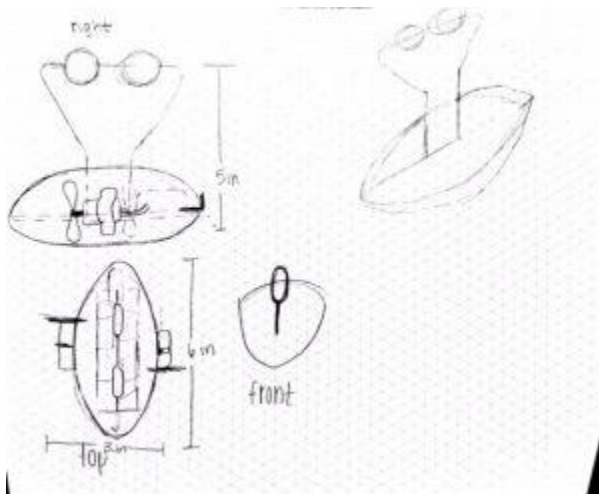
## Appendix

### -Attachments

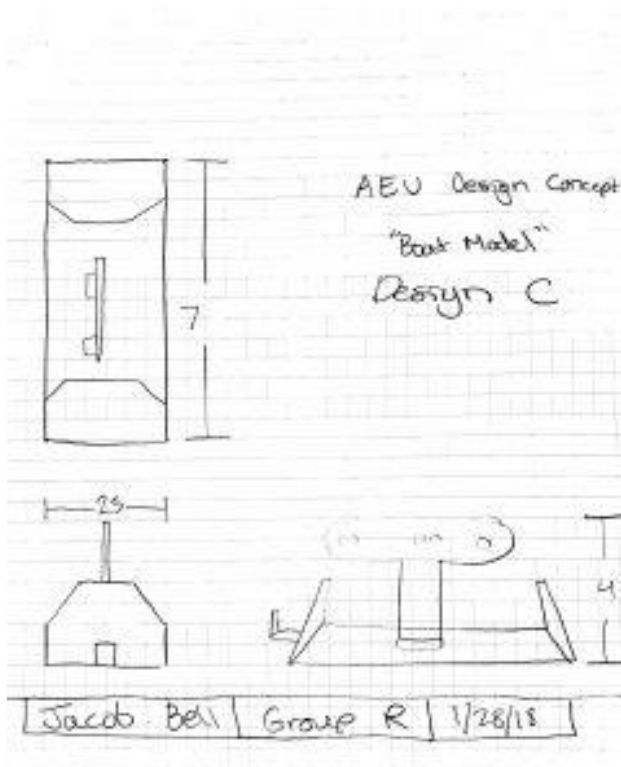
**Figure 1:** Individual Concept Design A. Costs approximately ~\$170,000.00



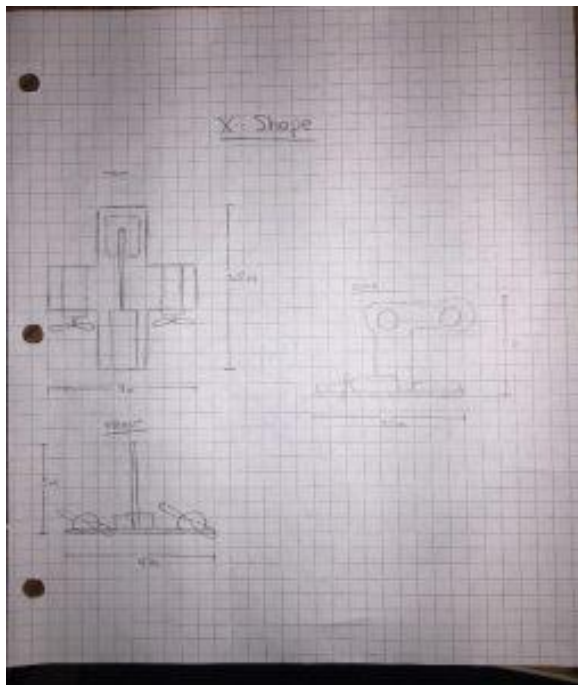
**Figure 2:** Individual Concept Design B. Costs approximately \$250,000.00



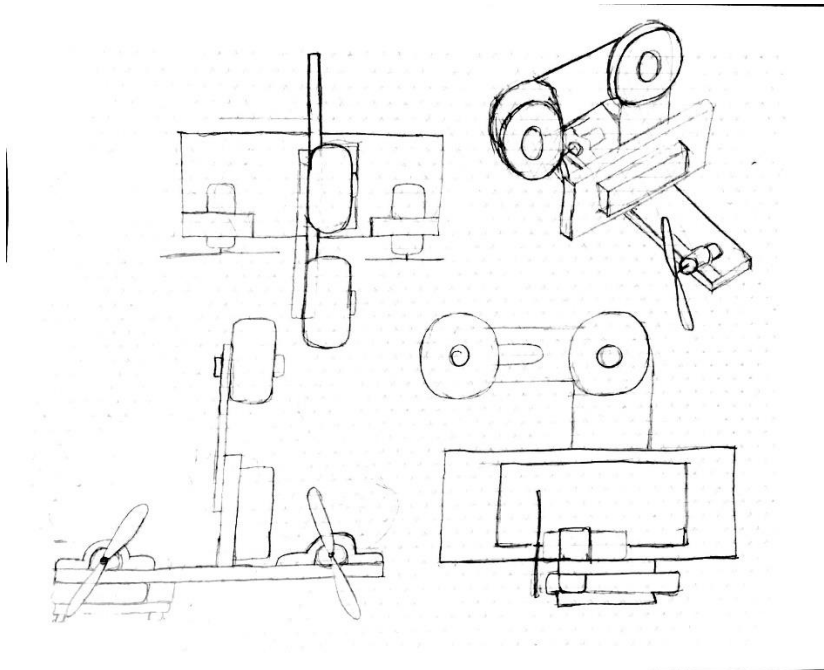
**Figure 3:** Individual Concept Design C. Costs approximately ~\$160,000.00



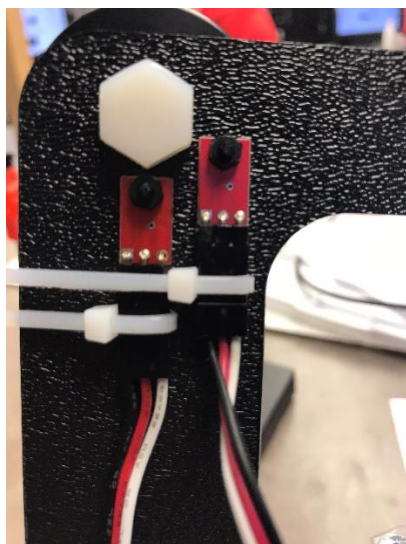
**Figure 4:** Individual Concept Design D. Costs approximately ~\$150,000.00



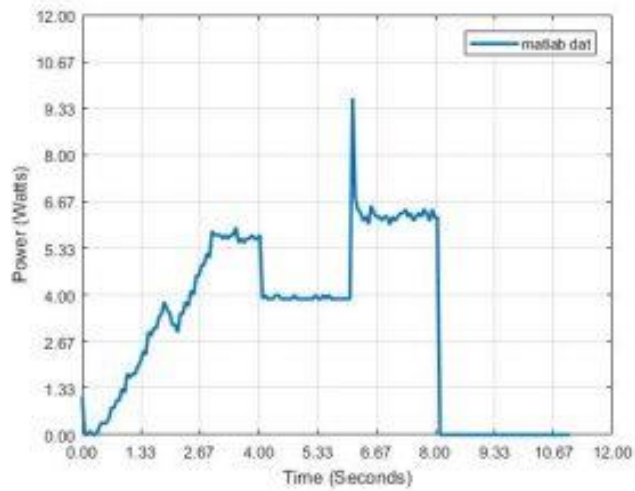
**Figure 5:** Team Concept Sketch. Costs approximately ~\$170,000.00



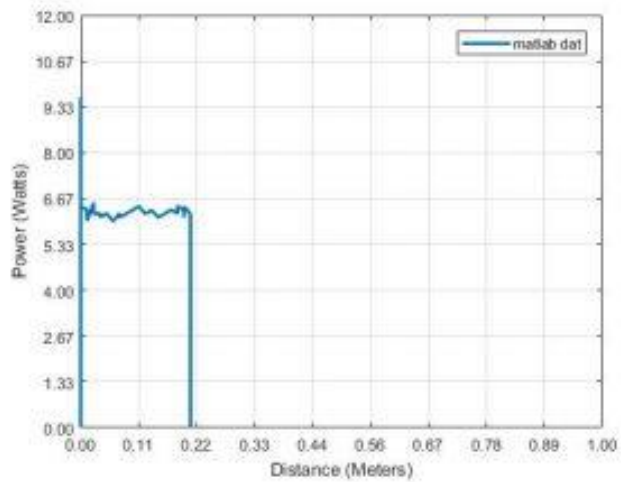
**Image 1:** The reflective sensors correctly attached to the arm of the AEV



**Graph 1:** Energy v. Time plot for the code used in the Data Analysis Tool lab (Code 2:1)



**Graph 2:** Energy v. Distance plot for the code used in the Data Analysis Tool lab (Code 2:1)



**Table 1:** Concept screening matrix. Used for quick assessment of the features of a concept model.

Success Criteria	Reference	Design A	Design B	Design C	Design D
stability	0	+	+	+	-
durability	0	-	+	+	+
aerodynamic	0	-	+	+	-
mass	0	+	+	-	+
cost	0	+	-	-	+
sum +'s	0	3	4	3	3
Sum 0's	5	0	0	0	0
Sum -'s	0	2	1	2	2
Net score	0	1	3	1	1
Continue?	combine	combine	combine	no	yes

**Table 2:** Concept scoring matrix. Used to apply weighted scores to the specific features of a model AEV

		REFERENCE		DESIGN A		DESIGN B		DESIGN C		DESIGN D	
Success Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
stability	20%	3	0.6	3	0.6	4	0.8	3	0.6	2	0.4
durability	15%	3	0.45	2	0.3	5	0.75	4	0.6	3	0.45
aerodynamic	10%	2	0.2	2	0.2	5	0.5	3	0.3	2	0.2
mass	30%	3	0.9	4	1.2	2	0.6	1	0.3	4	1.2
cost	25%	3	0.75	4	1	1	0.25	1	0.25	4	1
Total Score			2.9		3.3		2.9		2.05		3.25
Continue?		no		combine		no		no		yes	

## **-Codes**

### **Code 1:1 : Lab 1 - Scenario 1**

```
//Program between here
```

```
//Accelerate motor one from start to 15% power in 2.5 seconds.
```

```
celerate(1,0,15,2.5);
```

```
//Run motor one at a constant speed (15% power) for 1 second.
```

```
motorSpeed(1,15);
```

```
goFor(1);
```

```
//Brake motor one
```

```
brake(1);
```

```
// Accelerate motor two from start to 27% power in 4 seconds.
```

```
celerate(2,0,27,4);
```

```
// Run motor two at a constant speed (27% power) for 2.7 seconds.
```

```
motorSpeed(2,27);
```

```
goFor(2.7);
```

```
// Decelerate motor two to 15% power in 1 second.
```

```
celerate(2,27,15,1);
```

```
//brake motor two
```

```
brake(2);
```

```
//reverse the direction of only motor 2
```

```
reverse(2);
```

```
//Accelerate all motors from start to 31% power in 2 seconds.
```

```
celerate(4,0,31,2);
```

```
// Run all motors at a constant speed of 35% power for 1 second.
```

```
motorSpeed(4,35);
```

```
goFor(1);
```

```
// Brake motor two but keep motor one running at a constant speed (35% power) for 3 seconds
```

```

brake(2);
motorSpeed(1,35);
goFor(3);
//brake all motors for 1 second
brake(4);
goFor(1);
//reverse the direction of motor one
reverse(1);
//Accelerate motor one from start to 19% power over 2 seconds.
celerate(1,0,19,2);
//Run motor two at 35% power while simultaneously running motor one at 19% power for 2
seconds.
motorSpeed(2,35);
motorSpeed(1,19);
goFor(2);
// Run both motors at a constant speed (19% power) for 2 seconds
motorSpeed(4,19);
goFor(2);
// Decelerate both motors to 0% power in 3 seconds
celerate(4,19,0,3);
//brake all motors
brake(4);

```

## **Code 1:2 : Lab 2 - Scenario 2**

```

// Program between here-----

// run all motors for 2 sec at 25%
motorSpeed(4,25);
goFor(2);
// run all motors for 12ft at 20%
motorSpeed(4,20);
goToAbsolutePosition(123);

```

```
//reverse all motors
reverse(4);
//run all motors for 1.5 sec at 30%
motorSpeed(4,30);
goFor(1.5);
// brake all motors
brake(4);
// And here
} // DO NOT REMOVE. end of void myCode()
```

---

### **Code 2:1 : Lab 4 - Data Analysis Tool**

```
// Accelerate all motors from start to 25% in 3 seconds

celerate(4,0,25,3);

//Run all motors at a constant speed (25%) for 1 second

motorSpeed(4,25);

goFor(1);

//Run all motors at 20% power for 2 seconds

motorSpeed(4,20);

goFor(2);

//Reverse all motors

reverse(4);

//Run all motors at a constant speed (25%) for 2 seconds

motorSpeed(4,25);

goFor(2);

//Brake all motors

brake(4);
```

## **-Team Meeting Notes**

Group R Meeting 03

### **Date/Time/Location**

2/5/18

5:30 pm

Smith Lab

**Attendees:** Jacob Bell, Anna Goodge, Maycee Hurd, Chris Lipnicky

### **Agenda:**

- Complete concept screening + scoring
- Assign remaining parts for progress report
- Discuss group concept sketch

### **Summary:**

The team discussed the pros and cons of each other's designs through the screening and scoring process. Jake suggested that we should change one of the success categories to cost and the rest of the group agreed. We then decided that mass and cost were the most important factors in this project. Chris drew the team concept design after it was created. Parts of the progress report were then assigned to be completed individually that night

### **Upcoming tasks:**

- Conduct advanced research and development labs
  - Build the AEV design represented in the group concept design
  - Communicate with groups H + P to organize committee meeting
- 

Group R Meeting 03

### **Date/Time/Location**

1/22/18

6:00 pm

Smith Lab

**Attendees:** Jacob Bell, Anna Goodge, Maycee Hurd, Chris Lipnicky

### **Agenda:**

- Construct Model AEV
- Prepare for labs 3+4

### **Summary:**

The whole team worked together to configure the model AEV so that it was ready for testing the next day. Labs 3 and 4 were read through so that they could be started right away.

### **Upcoming tasks:**

- Sketch Individual Designs
  - Complete Labs 3+4
- 

Group R Meeting

### **Date/Time/Location**

Jan 15, 2018

4:00 pm

Morrill Tower

**Attendees**

Jake Bell, Anna Goodge, Chris Lipnicky, Maycee Hurd

**Agenda**

- Update website
- \*include contact information
- \*create division pages
- Complete meeting minutes
- \*upload to u.osu site
- Discuss schedule for team meetings and project management

**Meeting Summary**

The group updated the website with contact information and meeting notes. Anna and Maycee created the drop-downs for the website. Each team member added their information. When figuring out when to meet weekly, Jake suggested to meet on Tuesday evenings because of having lab earlier to that day. Discussed what needs to be researched before the next meeting. Those tasks can be seen below.

**Upcoming Tasks**

Create draft designs for the AEV components – ALL MEMBERS

Research software for designing AEV – ALL MEMBERS

\*Arduino

\*Solidworks

\* matlab

Read through MCR- ALL MEMBERS

Create Excel Sheet for costs