AEV Preliminary Design Review Report

Table I

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Class: Tuesday, Friday 1:50pm
Lab: Wednesday 2:20pm

Executive Summary

Throughout the semester, the group defined three essential mission statements for the overall design of the vehicle. While the class and the project specifically challenged and enabled students to undergo professional development in the engineering realm by means of problem solving, working as a team, presenting, and working with a timeline, table I emphasized simplicity, maximum energy efficiency, and low weight as specific group goals. These were essential to the development of the code and the vehicle since every major decision the group came to was supported by one of these three mission statements.

Never disregarding the mission statements, table I established a few objectives to ensure the completion of the overall project. Initially, all group members designed a craft that varied wing orientations, weight, propeller orientations, and the location of the main components. After submitting the designs, the group debated and assessed them, and using an original performance matrix, decided the best design to move forward. Using the performance matrix allowed the group to unbiasedly and quantitatively assess the quality of each of the four designs.

The two least heavy vehicles were chosen and were used to continue testing. Once the two designs were selected, they were assembled, and using the same codes, initially the team needed to ensure that both designs were capable of performing the needed task of picking up the other car with a magnet and return. After determining that they both possess the capacity to complete the task, the new criteria of differentiation was the energy used to complete the task.

Ultimately it was found that the design featuring the most streamlined base required less energy to travel the same distance as the other design and will most likely be selected as the design for final testing.

Considering the limited supply of energy readily available and the amount of time and resources required to continuously obtain and renew energy reserves, it is imperative that energy not be wasted. With that in mind, the vehicle designed for the task must not only minimize the amount of energy directly used by the motors, but it must also maximize energy efficiency to ensure that each burst of energy delivered to the engines induces the maximum amount of movement of the overall craft.

Overall, the team should implement the design which requires the least amount of energy while completing the mission. While keeping these goals in mind, the second of table I's two designs would most likely serve as a suitable design for this project since it emphasizes energy efficiency and is relatively simplistic to assemble which would allow for easier mass production than other designs.

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Introduction

Throughout this project, the group developed four distinct designs and over a period of roughly three months, narrowed the number of vehicle designs to two, built, assembled and compared the two vehicles. The primary criteria for the vehicles was to maximize the energy efficiency of the vehicle and minimizing the amount of needed energy to complete the task. Group I specifically prioritized low weight since they predicted that it would minimize weight and maximize the simplicity.

Experimental Methodology

This project is to assemble a AEV and write the codes to control it run on the track following the requirements.

In the lab 1, the team got the kit and knew each components what are they used for. Then, the team set up the AEV software and got familiar with the codes which would be used to control the AEV position and speed. In the project, the problem solving method is very important way to solve the problems which would show in the project. In the first lab, equipment was used including AEV motor mount stand, AEV controller, two motors, USB Cable and Li-Po Battery. The AEV controller is a significant part of the AEV. This part is used to control the AEV's power output and distance. Moreover, it can record the system data which would be useful to improve the AEV's energy efficiency. There are several commands that are used in the lab. The command "celebrate" is used to accelerate or decelerate the speed of the motor; the command "motorSpeed" is used to control the power of the motor; the command "goFor" is used to control the AEV to run at the same speed in indicated seconds; the command "brake" is used to stop the motor; the command "reverse" is used to change the rotation direction of the motor. Arduino sketchbook should be set up because in order to run the codes, the codes should be located somewhere in the computer.

In the lab 2, the team assembled the AEV according to the sample which is given in the lab manual. In the process of constructing the AEV, the team became more familiar with the lab equipment and got ready for future lab. In this lab, the external sensor was used. The team install the sensor and test it. There are two codes used to contol the distance travled, the command "goToAbsolutePosition" and "goToRelativePosition". The differences between these two codes is absolute position means travel to the point which are indicated and relative means travel to a point relate to initial point. In addition, the team did the wind tunnel test. This task is to test two different propeller designs which one is more efficient. One of the team member collect the data in the wind tunnel test and these data can be used to analyze and calculate the power input, power output, power efficiency and propeller advance ratio.

In lab 3, all of the teammates did brainstorming and design their own AEV. In the lab 4, the team write codes to run the AEV to collect the data from the automatic control system and convert these data to physical parameters. After, the team did performance analysis including calculating power and incremental energy and use graph to express these data. In this lab, the team also used Matlab to analysis the data.

In the lab 5, the team determined the success criteria to fit the designs and use concept screening scoresheet and concept scoring matrix to determine which design is the best. The lab marked 6 is midpoint of the whole project. The team reviewed what we have did and what we plan to do in the future labs. In lab 7, the team presented the progress of the AEV as well as future plans to the class.

Results

The group went forward with two very similar designs; very simplistic, with the only thing varying between the two is the base used. This was after the fact the first initial two initial design was narrowed down to one; but then a new base was created. The first design used all generic parts given other than the rubber bands used to secure the battery. The other design utilized a custom, laser cut base. This base was approximately 45% lighter than its counterpart as it removes parts that are not essential to the structure of the AEV. With the decrease in weight it is predicted that the energy expelled while performing the task will decrease. This however can not be proven due to the fact that it has not been put to the test due to a delay in the creation of the base. With the time given the team came to the consensus to invest time in perfecting the code for the mission. The group created two different scenarios. One being to go at a higher speed for a shorter amount of time or operate at slower speeds for a longer amount of time. In terms of the propellers used the team performed a very brief experiment to decide which ones to use. A very simple code with a set amount of power was created. The propellers were tested with the same code, specifically the same amount of power, and it was obvious that the AEV moved much more smoothly and efficiently with the push method. With the data, the code will be used with the design that the team finalized.

Concept Screening

Table 1: Concept Screening Matrix to Determine Leading AEV Designs

Success Criteria	Reference	Tyler's	Albert's	James'	Carlos'
Balanced Turns	0	+	0	0	0
Center of Gravity	0	+	+	0	+
Weight	0	-	+	0	+
Cost	0	-	0	0	0
Simplicity	0	-	+	0	+
Maintenance	0	+	+	+	+
Durability	0	-	0	0	0
Aerodynamics	0	+	0	+	0
Aesthetics	0	+	0	-	0
Sum of +'s	0	5	4	2	4
Sum of 0's	9	0	5	6	5
Sum of –'s	0	4	0	1	0
Net Score	0	1	4	1	4
Continue?	No	No	Yes	No	Yes

Concept Scoring

Table 2: Concept Scoring Matrix to Determine Best AEV Design

		Reference		Albert's		Carlos'	
Success Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Balanced Turns	**15%**	**4**	**0.60**	**5**	**0.75**	**4**	**0.60**
Center of Gravity	**15%**	**4**	**0.60**	**5**	**0.75**	**5**	**0.75**
Weight	**20%**	**4**	**0.80**	**4**	**0.80**	**3**	**0.60**
Cost	**10%**	**5**	**0.50**	**4**	**0.40**	**4**	**0.40**
Simplicity	**10%**	**4**	**0.40**	**5**	**0.50**	**4**	**0.40**
Maintenance	**10%**	**5**	**0.50**	**5**	**0.50**	**5**	**0.50**
Durability	**14%**	**4**	**0.56**	**5**	**0.70**	**5**	**0.70**
Aerodynamics	**3%**	**5**	**0.15**	**4**	**0.12**	**5**	**0.15**
Aesthetics	**3%**	**4**	**0.12**	**3**	**0.09**	**5**	**0.15**
Total Score			**4.23**		**4.53**		**4.25**
Continue?			**No**		**Yes**		**no**

The two sets of code behaved very differently as the slower took a lot longer to complete the mission. After extracting the data, the group determined that by running the AEV at 25% and 40% power for the forward and return trips, respectively, but for a shorter period of time, used 215.50 Joules of energy. When run at the lower power settings of 18% and 32%, the AEV used 473.53 Joules instead as the AEV had to run for much longer to reach the marks. It was made evident that faster one expelled a significantly less amount of energy. We initially expected the lower power settings to use less energy but after observing the AEV run we realized why that was not the case. Although the AEV ran on lower power settings, it ran much slower and longer, increasing the total amount of energy expended as the higher power setting code ran for a much shorter period of time, as shown in figure 3. Experience from the system analysis tests allow the group to identify the phases of the AEV energy vs time graphs to determine what specific sections of code should be improved on to improve efficiency or reduce energy usage. The test made it clear the team should use the higher power code on the custom designed AEV base. The group is confident a substantial reduction in energy can be achieved with additional tests and optimization to be performed next lab with the fast code.

Figure 1: Power used by AEV vs Time for High Power Setting

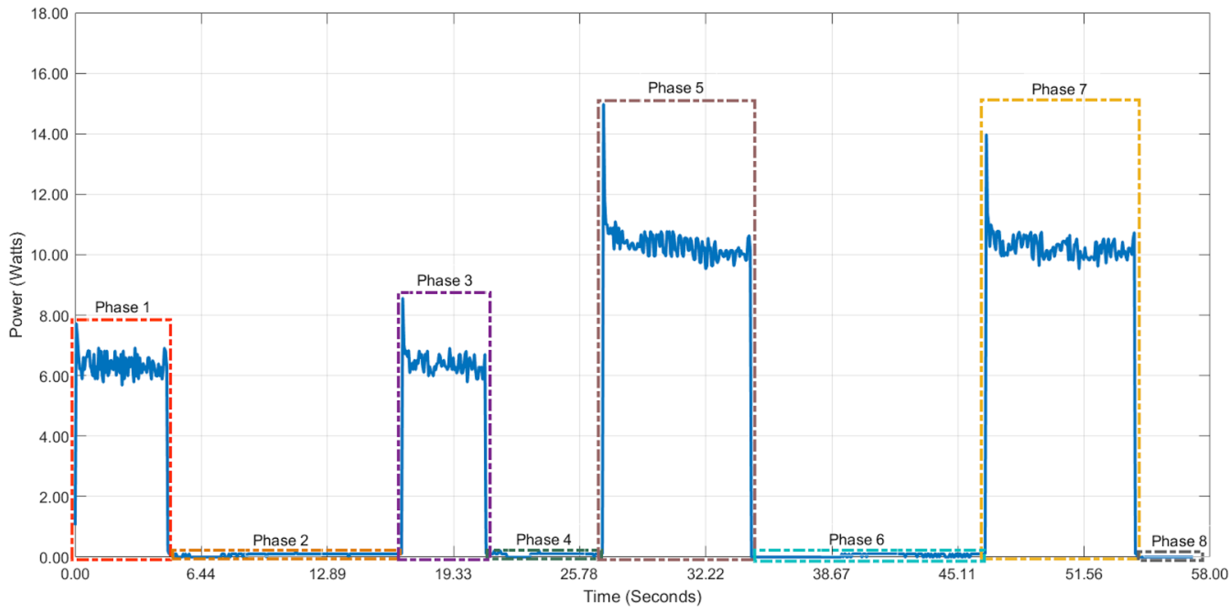


Figure 2: Power used by AEV vs Time for Low Power Setting

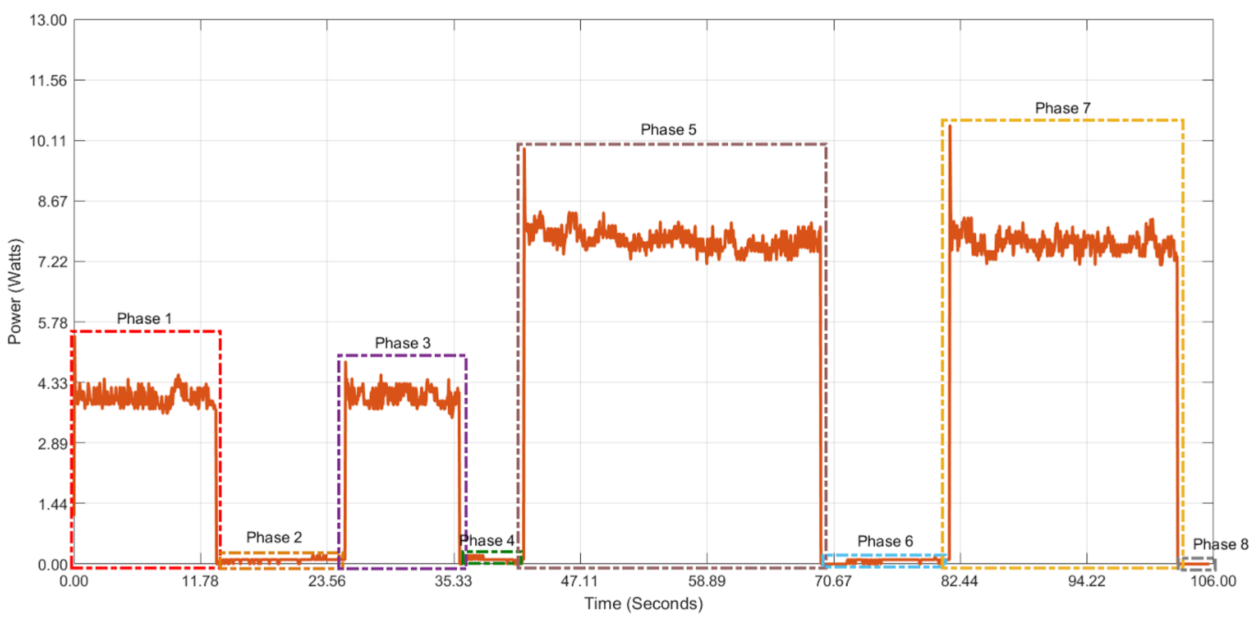
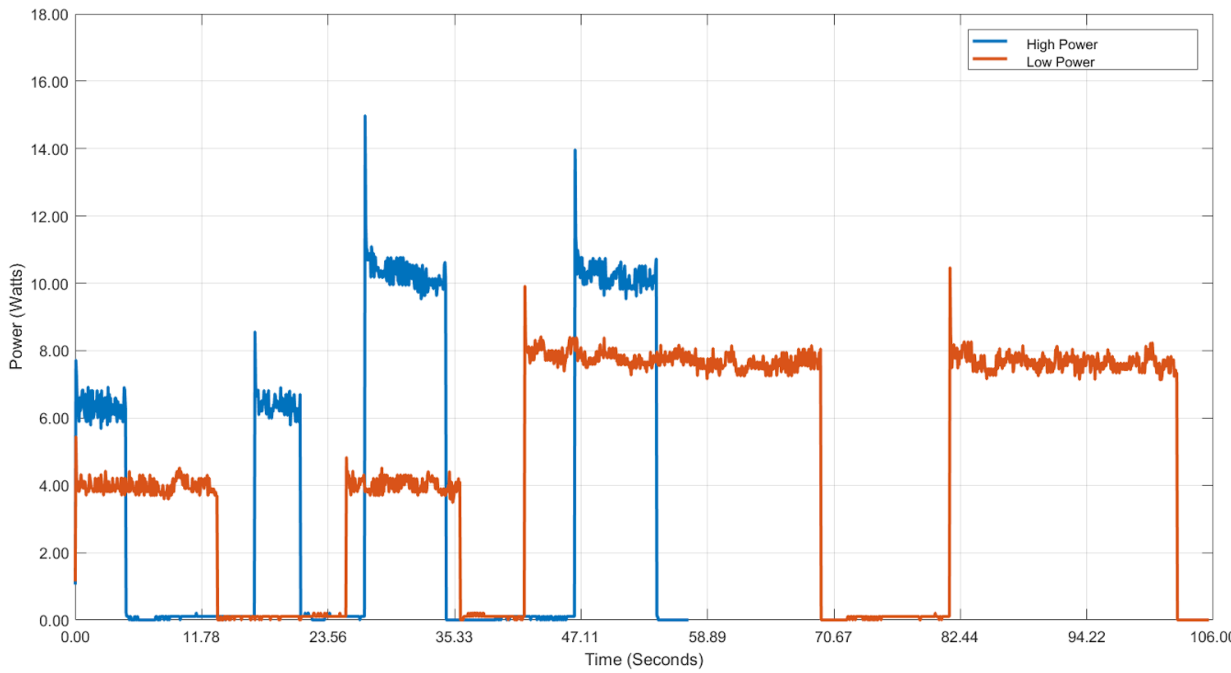


Figure 3: Power used by AEV vs Time for Both Power Settings



As can be seen in figures 1 and 2, the AEV run was split into eight distinct phases, each representing the same for each run. Phase 1 is the initial constant motor speed run and phase 2 represents the braking and coasting to a stop while repeating for phases 3 and 4. Starting in phase 5, the AEV reverses direction and runs at an increased constant speed, before braking and coasting again in phase 6 and repeating for phases 7 and 8.

Table 3: Raw AEV Data for High Power Run

Time (ms)	Current (cts)	Voltage (cts)	Marks (cumul)	Position (marks)
0	10	554	0	0
10020	1	554	390	390
20040	56	543	515	515
30000	105	534	853	763
40020	1	552	1186	430
50040	98	533	1250	366
57120	0	550	1542	74

Table 3: Raw AEV Data for Low Power Run

Time (ms)	Current (cts)	Voltage (cts)	Marks (cumul)	Position (marks)
0	11	548	0	0
15001	1	546	364	364
30001	42	540	469	469
45001	79	532	827	789
60001	72	530	1101	515
75001	1	543	1175	441
90001	74	529	1316	300
105601	0	541	1625	29

Conclusion and Recommendations

After designing the four different models, assessing and choosing the top two, sketching out and laser cutting the parts and testing them, the group is essentially ready to declare one model the prototype for final testing. Ultimately, after weeks of development, table I will most likely declare the design with the more streamlined base as the design for final testing. Since the needed parts were just recently obtained, not all of the data needed to compare the two final designs have been acquired, but if the estimated calculations are correct, the streamlined model will serve as the final design.

Furthermore, the code developed specifically reduces the amount of energy inputted into the system and therefore embodies the mission statement of not wasting energy. If more designs were submitted, potentially more variety could be obtained in the deliberation process. Also if there were more rounds of design submissions, the final design could incorporate revisions and could be improved more so than it would with just one or two review sessions. In addition to this, if teams were five or six people, more designs and ideas could be discussed and presented for the vehicle since more diversity would exist. This would allow for a greater circulation of ideas and a potentially better overall AEV.

Going forward, table I will finalize testing for the streamlined model and will finalize the code for the assignment as well. This will most likely take two to three weeks. In addition, prepare a report presentation to accompany the performance test and debrief the instructor on the design for the final design review. This has ultimately granted the team more patience and appreciation for teamwork and the design process but also emphasized the need to understand math and physics as they most certainly pertain to the real world.

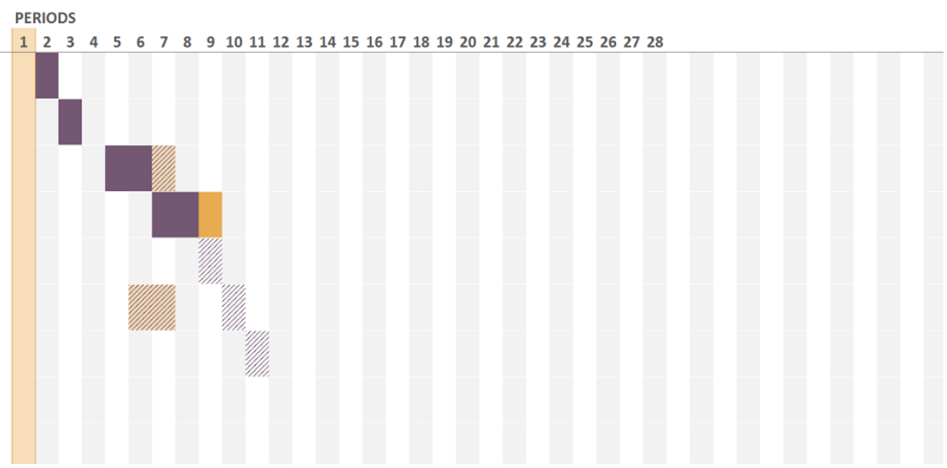
Appendix

Figure 4: Schedule

AEV Project Te am I

Select a period to highlight at right. A legend describing the charting follows. **Period Highlight:** 1 — Plan Duration, Actual Start, % Complete, Actual (beyond plan), % Complete (beyond plai

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Design Brain Storming	2	1	2	1	100%
Descision Matrix	3	1	3	1	100%
Testing of 2 Designs	5	2	5	3	75%
Development of 2 codes	7	2	7	3	100%
Finalize Design	9	1			0%
Energy Optimization	10	1	7		0%
Final Test	11	1			0%



**Note: the numbers correlate with the labs the team has had in class. Also theactual start for energy optimization, it has no occured. The actual start is an error.*