Group J - Matthew Caldwell, John Kim, Jacob Phillips, Tarun Pilli Lab 7 Executive Summary

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Executive Summary

The AEV Energy Model Lab involved testing and modifying the group's AEV design to minimize wheel count sensor error. Then, the group tested the modified design, using obtained data to make observations and calculations about the performance of the AEV. Minimizing the sensor error allowed for greater consistency between test runs, resulting in more usable data for determining the quality of the design. This allowed for a consistent Energy Model that could be used to numerically describe and compare the performance of the different groups' AEV designs in an objective manner.

During the lab, a test run was performed with the group's AEV on the straight track, with the distance in inches being recorded from the tape measure along the track. The measured value was converted to the equivalent value of marks of rotation of the wheel count sensor, and compared to the marks travelled obtained from the Arduino's EEPROM data. The team's values differed by 12 marks of error, exceeding the maximum allowed error of 2 marks. The team's first attempt to resolve this was re-applying the reflective tape on the wheel that the sensor measures, but trials after this fix still resulted in around the same level of error. Next, the team counterbored the holes that the wheel count sensors were screwed into, such that the screw heads would be flush with the arm and not interfere with the readings. This also failed to change the resulting amount of error. The group was able to finally resolve the error to two marks by replacing one of the wheel count sensors.

With a consistently performing AEV, the group was then able to perform the test described by the AEV Energy Model. This test had the AEV motors run at a constant speed for four seconds and then stop, allowing the AEV to coast to a halt. The model divides the run into two phases, the first being the constant motor speed portion and the second being the coasting portion. Zero aerodynamic drag force is assumed, as the actual value is so small its effect is negligible. As such, the force causing the AEV to stop is considered the frictional force between the wheels and the track and within their bearings. Friction is acting on the AEV during both phases. During Phase 1, the force of the propeller is applied; friction acts in the direction opposing this applied force. With this precise model to describe the AEV's motion, EEPROM data collected from the test run could be manipulated with known mechanics equations to calculate the propeller and friction forces experienced by the AEV.

As seen in Figure 1, located in the appendix, the group's AEV experienced a propeller force of 10.4 gm, a friction force of 3.5 gm, and a total net force of 6.9 gm. The propeller force denoted the main force pushing the AEV, whereas the friction force described the force directly opposing the force putting the AEV in motion. The friction force is based upon the mass of the AEV - the higher the design's mass, the higher the friction force. This can be said for all forces, as force is notated by Newton's famous equation, F=ma. For the group, it was important that there was a significant difference between the

propeller force and the friction force, as that difference, otherwise known as the net force, is the force that advances the AEV. Ideally, the net force should have been as high as possible, allowing for maximized efficiency. The class average for the propeller, friction, and net forces were 11.2 gm, 4.7 gm, and 6.5 gm, respectively. This information can also be found in Figure 1, designated in the appendix. While the group's AEV experienced a relatively less propeller force, the group's AEV also experience a lower friction force and a higher net force. Since the group's net force was higher than the average, it can be said that the group's AEV is, comparatively, superior to others with regards to efficiency. To further improve the AEV's performance, the group could search for ways to lower the mass of the design, lessening the friction force acting on the wheels.

Graphs of the AEV's distance and velocity can be found in the appendix, in both Figures 1 and 2, respectively. Observing the trends of these data shows a clear division between the phases of the AEV's motion described in the Energy Model. Figure 1, which describes the AEV's travelled distance with respect to time, has a point of inflection at 4 seconds. This aligns with the critical point on Figure 2, the velocity vs. time graph, where the velocity changes from increasing to decreasing. These results are consistent with the program described by the Energy Model's code, as the point 4 seconds in is when the applied propeller force ceased and the only remaining force, friction, began to slow it to a stop.

Overall, Team J proceeded through the AEV Energy Model Lab smoothly, but not without assistance from the instructional team. The team encountered multiple complex errors with the AEV design that was being tested that would not have been identified without the proper guidance. The reflective tape on the wheel that the sensors used to measure distance was not properly aligned and had to be centered by a teaching assistant. Also, the screws used to connect the sensors with the arm were not completely flush and had to be counterbored. Although redesigning the AEV in each instance decreased the mark error, Team J would never have known to do either renovation without help from the instructional team. The lab procedure could have been more precise by providing possible sources of error as to allow teams to work together to create a solution. Problem solving was an important part of the lab, but many of the problems that needed to be overcome were too subtle for the teams to fix without assistance. Another possible point of improvement for the lab procedure would be more clearly explaining the concept of the AEV Energy Model and how it allowed for the groups to compare their data. The idea is explained to an extent in the Lab Procedure, but its full meaning and relevance is somewhat unclear at first. The background information could be presented in a more linear fashion in the Lab Procedure in order to enhance clarity.

Lab 7 exhibited various troubleshooting methods to the group. Overall, various issues and solutions were explored, giving the group more insight about the AEV and its many components. Lab 7 was designed for groups to take advantage of sensor testing, and Group J efficiently used the lab period to pinpoint a problem, and troubleshoot until the issue had been finally resolved. Lab 7 also provided the group with an objective model through which AEV performance could be tested, observed, and compared. In the future, the insight gained here will assist the group with upcoming issues regarding the AEV design.

Appendix

Sample Data

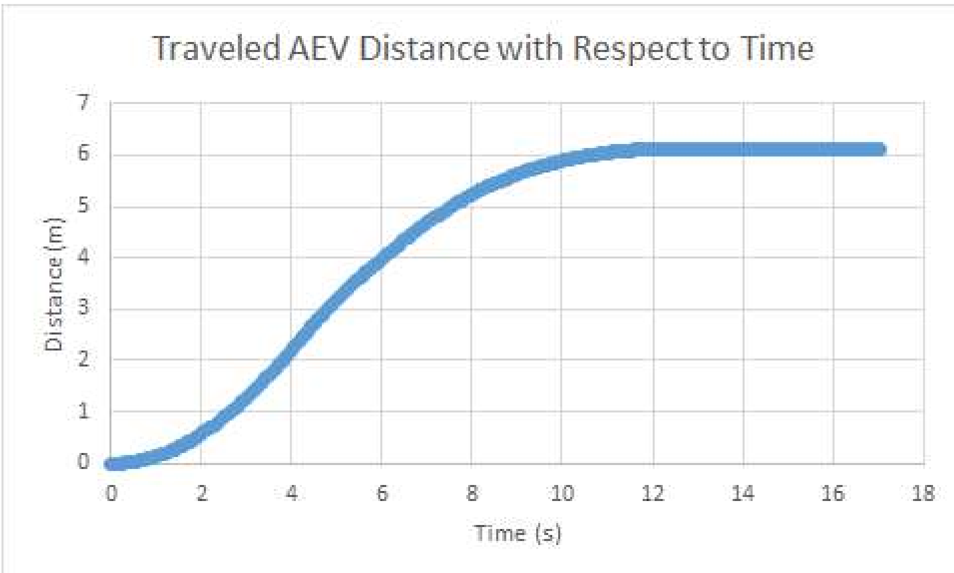

Figure 1: Distance Traveled By AEV with Respect to Time

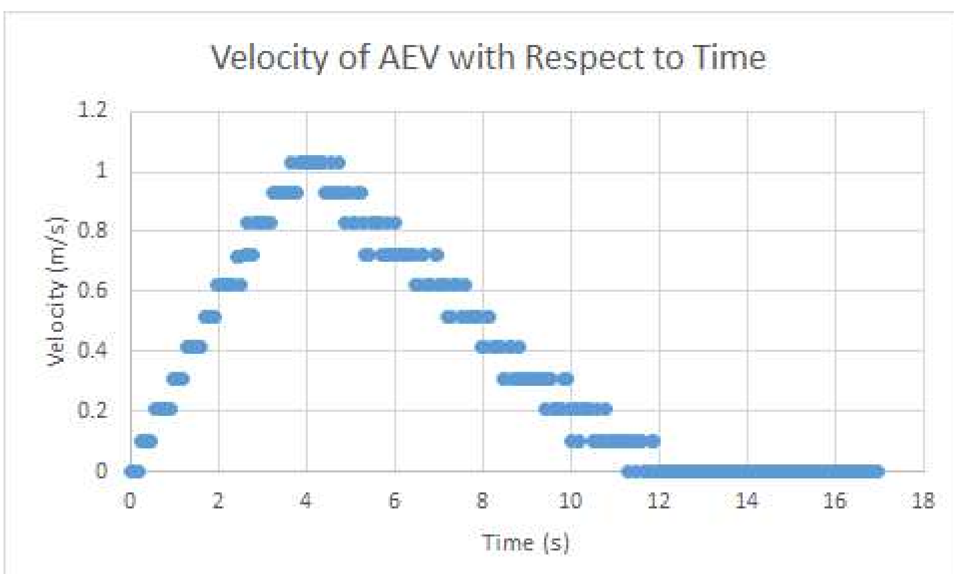

Figure 2: Velocity of AEV with Respect to Time

Table 1: Class Composite Data

Team	Motor Percent	$F_{propeller}$ (gm)	$F_{friction}$ (gm)	F_{net} (gm)	Marks Error
A	30	12.4	5.3	7.1	1
B	30	15.5	5.2	10.3	2
C	30	8.0	2.8	5.2	2
D	30	9.4	7.7	1.7	15
E	30	34.0	13.9	20.1	2
F	30	8.6	2.5	6.1	2
G	30	8.4	3.1	5.3	1
H	30	10.6	6.9	3.7	0
I	30	8.6	2.6	6.0	5
J	**25**	**10.4**	**3.5**	**6.9**	**2**
K	30	10.5	4.1	6.4	1
L	30	7.9	3.0	4.9	0
M	30	9.4	2.7	6.7	1
N	30	9.5	4.8	4.6	1
O	30	11.6	6.2	5.4	7
P	30	7.8	2.6	5.2	7
Q	30	9.2	4.2	5.0	6
R	30	10.2	3.9	6.3	11
Class Average		11.2	4.7	6.5	3.7