Group O-Katie Gonsoulin, Jessica Hudak, Melanie Gross, Jennifer Bertrand Progress Report Week 2
Instructor- Dr. Busik, GTA- Melissa Hrivnak 1/29/17

Week 2

Situation

In the first section of Lab 2, team members completed the construction of the concept AEV and became familiar with the external sensor hardware components, troubleshooting techniques, and program function calls for utilizing external sensors with AEV control. The team learned about the purpose of reflectance sensors as well as the test that ensures proper installation of reflectance sensors. The students practiced coding with new function calls as well as with the function calls that were introduced in the previous lab (for braking, reversing, and setting the speed of the motors). The difference between the goToRelativePosition(m) function and the goToAbsolutePosition(m) function was emphasized, and the conversion from marks to distance travelled was noted. The team utilized this knowledge of function calls for programming the code for the Outside Track Scenario.

The second part of Lab 2 allowed the team to investigate propulsion system efficiency as they became familiar with the equipment for wind tunnel testing. The wind tunnel simulated an AEV in motion without the need of the entire AEV, just the AEV propulsion system (the propeller and motor). The wind tunnel testing let the team determine the efficiency of the AEV propulsion system by measuring the power output from the electric motor and the propeller (using a thrust stand) once a certain input power (current and voltage) was set. Different propeller configurations (puller and pusher) were introduced. The propulsion system was tested under various conditions and data was collected in order to ultimately determine the settings that produce maximum efficiency. Students were provided with the equations for propulsion efficiency percentage, propeller advance ratio, thrust calibration, power input, and power available for the necessary data analysis.

Results and Analysis

This lab had two major focuses, writing more code that utilized new Arduino commands and performing wind tunnel tests on the propellers to determine which propellers would be most efficient. Three team members worked on writing the code for the AEV while the fourth was collecting data from the wind tunnel tests to be used in calculations later. There were no complications with writing the code from the instructions provided, but when the team tried to run the code on the AEV it did not start moving right away, it required a small push to start its journey. The wind tunnel portion of the lab had a few setbacks, leading to incorrect data being collected. This led the team to discard one set of data and use the other data collected to make conclusions regarding the propellers.

The code used in this portion of the lab will help the team when writing the the preliminary code to complete the scenario stated in the MCR. This lab provided the code that will be used in determining how far the AEV will travel while running on the track. The new commands learned will be combined with previously learned commands to complete the mission with the best possible energy efficiency.

Comparing the results of the 2 3030 propeller trials, Trial 2 seemed to be more accurate than Trial 1 due to Trial 1's incorrectly negative results. Trial 1 of the 3030 propeller resulted in negative calibrated thrust, power output, and propulsion efficiency, which are all imprecise results. The more accurate data for the 3030 configuration showed propulsion efficiency versus the advance ratio at a steeper slope than the 2.5 inch blade, 2510 setup, as seen in Figures 2 and 6 in the appendix. Therefore, it was determined that it is more efficient to use the 3 inch propeller blade, 3030 setup. The 3030 setup showed a greater increase in this percentage as opposed to the 2510 values, reflecting the the 3 inch blade was more efficient as the power input increased. Also, the pusher configuration proved to be better than the puller configuration since it generated more thrust and had higher power output values, as seen in Table 3 and 6.

One potential error in this lab was the construction of the AEV. The AEV was not balanced properly and was leaning forward. This error could have been part of the reason why the AEV did not travel initially after starting the program. This error was resolved by rebuilding the AEV and switching the positioning of the arm, Arduino, and battery to make the vehicle more balanced. Another error in the lab was the incorrect propeller was used while collecting data. This error was resolved by discarding that data collected and basing conclusions about the different propellers on other data collected. Trial 1 of the 3030 propeller yielded negative calibrated thrust, power output, and propulsion efficiency, which are all imprecise results. This is likely a result of imprecise calibration of the thrust scale, as this trial's readings were quite low relative to the other trials performed.

Takeaways

Noteworthy takeaways from the first section of this lab centered around the identification and purpose of the various external sensor hardware components, troubleshooting techniques, and function calls. The value of reflectance sensors was learned as well as the test that verifies if reflectance sensors are installed correctly. The lessons of old function calls (from last week) were reinforced and new function calls were introduced, such as the goToRelativePosition(m) function and the goToAbsolutePosition(m) function.

The second section of this lab introduced the concepts of propulsion system efficiency and wind tunnel testing and allowed students to apply this knowledge for determining the efficiency of the AEV motor and propeller. The team also learned about different propeller configurations (puller and pusher). Additionally, the team learned how to perform data analysis for determining the condition that produced maximum efficiency.

Right after the team placed the AEV on the track, the team realized that the code did not supply adequate power for the AEV to move as desired. Although the motors began running after the start button was pressed, the AEV needed a small push start from one of the team members before the AEV actually started moving on its own. The AEV made it to the first bend in the outside track at an extremely slow pace before it stopped moving completely. The team realized that in order to fix this issue, the code needed to be tweaked so that a greater power setting would be supplied. This solution should allow the AEV to travel faster on the track. The team did not have enough time to test the AEV again on the track after the code was fixed, so it still cannot be concluded for certain whether or not it would now be able to successfully travel to the gate and stop.

Given that the data from Trial 2 of the 3030 propeller was more precise than Trial 1, the team will likely disregard the imprecise results of the first trial and accept the second trial's results as accurate. Comparing the results of the 3030 propeller and the 2510 propeller, the team noted that the 3030 propeller was more efficient as power input increased. Because this 3 inch propeller produced more thrust and outpower, the team will likely use the more efficient 3030 propeller.

Upcoming Goals

In the upcoming lab, the team will begin to brainstorm designs for the AEV. On orthographic drawing paper, each team member will construct a preliminary drawing of a potential design for the AEV. Then, the team will collaborate to compile each sketch into an overall design for the AEV. This technical sketch will also be completed on orthographic drawing paper. It will be important for the team to keep in consideration that aesthetically appealing designs are vital in attracting consumers, as well as a fully functioning product. In order to enhance creative design thinking, the team may engage in some of the suggestions listed in the lab manual such as keeping a journal, engaging in relaxing activities or reading. Following the guidelines in the AEV lab manual, the team will work to construct and AEV that is visually appealing and exciting while maintaining energy efficiency, weight efficiency and full functionality.

This week, the team will complete the progress report, update the project portfolio and engage in relaxing techniques to encourage creative thinking for the upcoming lab. The progress report and project portfolio will be updated by Wednesday, February 1st in order to comply with the given deadlines and have the necessary tasks completed before lab on Thursday, February 2nd. After completing the lab on Thursday, the website will be updated again, another progress report will be written, and the team will move closer to finalizing an AEV design. The team will meet again on Sunday, February 11th and the upcoming tasks will be completed by Thursday, February 9th. These tasks should offer any difficulty to complete in the allotted time.

Weekly Schedule

Table 1: Week 2 Schedule

		Task Mode	Task Name	Duration	Start	Finish	% Complete	Jennifer Bertrand	Melanie Gross	Katie Gonsoulin	Jessica Hudak
1	✓		u.osu Website Creation	1 hr	Sun 1/22/17	Sun 1/22/17	100%	1 hour	1 hour		
2	✓		Progress Report Lab 2	32 hrs	Sun 1/22/17	Wed 1/25/17	100%	1 hour	1 hour	1 hour	1 hour
3	✓		AEV Concept Design	1 hr	Sun 1/22/17	Sun 1/22/17	100%			1 hour	
4	✓		Creation of Gant Chart	30 mins	Sun 1/22/17	Sun 1/22/17	100%		30 minutes		
5	✓		Team Meeting Notes 1	30 mins	Sun 1/22/17	Sun 1/22/17	100%	30 minutes			
6			Progress Report Lab 2	4 days	Sun 1/29/17	Wed 2/1/17	50%	1 hour	1 hour	1 hour	1 hour
7	✓		Project Portfolio Update	1 day	Sun 1/29/17	Sun 1/29/17	100%	1 hour	1 hour		
8			Wind Tunnel Calculations	4 days	Sun 1/29/17	Wed 2/1/17	50%			2.5 hours	
9	✓		Team Meeting Notes 1	1 day	Sun 1/29/17	Sun 1/29/17	100%	30 minutes	30 minutes		
10	✓		Update Gant Chart	1 day	Sun 1/29/17	Sun 1/29/17	100%		15 minutes		

Appendix

Table 2: Wind Tunnel Testing Data First 3030 Pusher

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
-0.1	11.7	0	0
0	11.4	2035	10
0.09	9.4	3035	15
0.18	7.5	3892	20
0.28	5.3	4610	25
0.38	2.2	5449	30
0.48	2.9	6167	35
0.58	3.5	6826	40
0.66	7.2	7425	45
0.77	11.2	8043	50
0.86	15	8682	55
0.97	19.5	9481	60

Table 3: Wind Tunnel Data Analysis First 3030 Pusher

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Horsepower*	*Watts*	*%*	*--*
0.0000	0.000	0.000	0.00000000	0.00000	0.000	0.0000
-0.1233	2035	0.000	-0.00000438	-0.00326	0.000	62.6826
-0.9453	3035	0.0999	-0.00003356	-0.02503	-25.053	42.0293
-1.7262	3892	0.2664	-0.00006129	-0.04570	-17.156	32.7747
-2.6304	4610	0.5180	-0.00009339	-0.06964	-13.444	27.6701
-3.9045	5449	0.8436	-0.00013863	-0.10337	-12.254	23.4096
-3.6168	6167	1.2432	-0.00012841	-0.09576	-7.702	20.6841
-3.3702	6826	1.7168	-0.00011966	-0.08923	-5.197	18.6872
-1.8495	7425	2.1978	-0.00006567	-0.04897	-2.228	17.1797
-0.2055	8043	2.8490	-0.00000730	-0.00544	-0.191	15.8596
1.3563	8682	3.5002	0.00004815	0.03591	1.026	14.6924
3.2058	9481	4.3068	0.00011382	0.08488	1.971	13.4542

Table 4: First 3030 Propeller Data Settings

Wind tunnel air speed:	2.7	m/s	
Propeller configuration:	3030 Pusher	0.0762	m
Battery (Power Supply Setting):	7.4	volts	

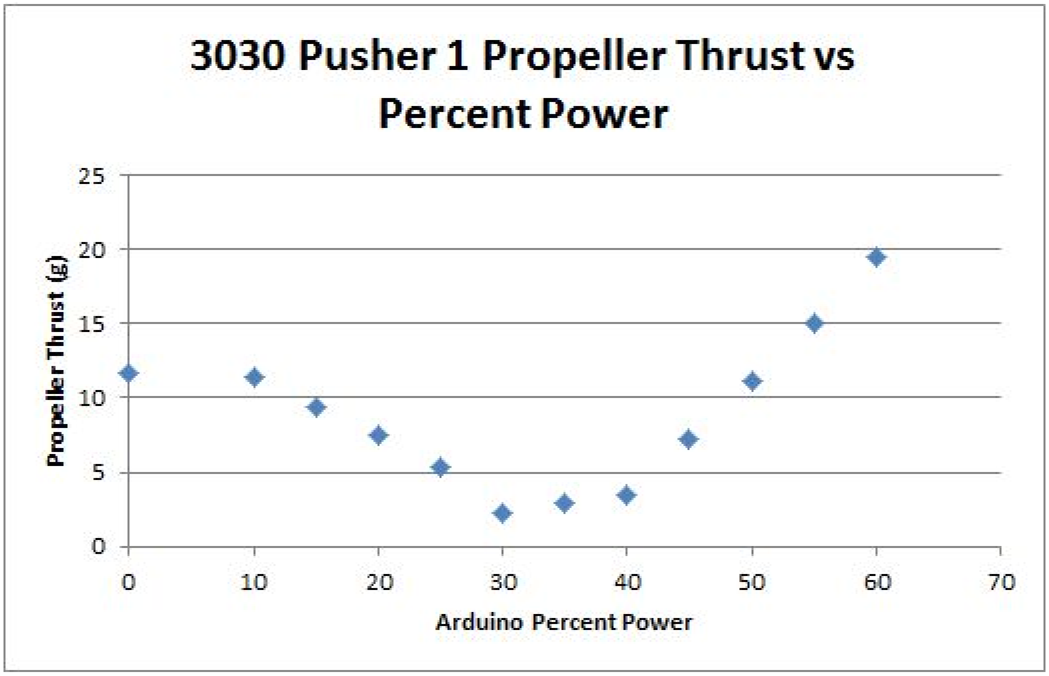

Figure 1: 3030 First Pusher Propeller Thrust vs Percent Power Graph

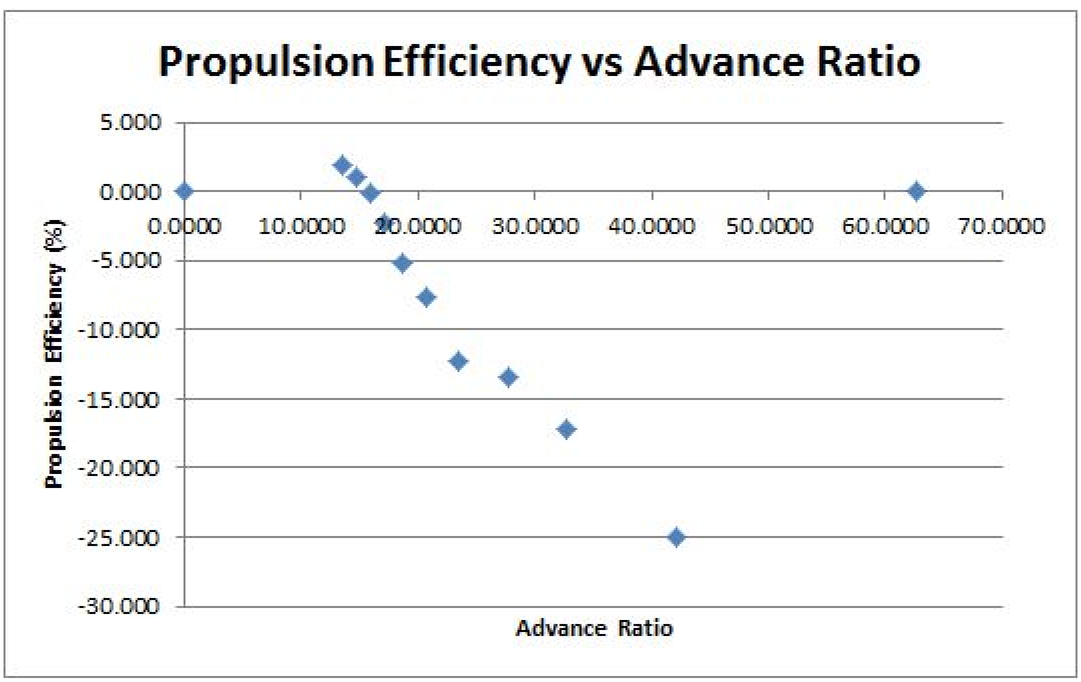

Figure 2: 3030 First Pusher Propeller Advance Ratio vs Propulsion Efficiency Graph

Table 5: Wind Tunnel Testing Data Second Pusher 3030

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	156.5	0	0
0.01	157	2035	10
0.08	159	2994	15
0.19	161	3892	20
0.28	163.5	4610	25
0.39	166	5389	30
0.49	169.5	6107	35
0.59	173	6766	40
0.68	177	7485	45
0.78	180.4	8143	50
0.88	185	8802	55
1.02	193	9760	60

Table 6: Wind Tunnel Data Analysis Second 3030 Pusher

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Horsepower*	*Watts*	*%*	*--*
0.0000	0.000	0.0000	0.00000000	0.00000	0.000	0.0000
0.2055	2035	0.0074	0.00000757	0.00564	76.247	65.0042
1.0275	2994	0.0888	0.00003783	0.02821	31.770	44.1829
1.8495	3892	0.2812	0.00006810	0.05078	18.058	33.9886
2.8770	4610	0.5180	0.00010593	0.07899	15.249	28.6949
3.9045	5389	0.8658	0.00014376	0.10720	12.382	24.5469
5.3430	6107	1.2691	0.00019673	0.14670	11.559	21.6610
6.7815	6766	1.7464	0.00024969	0.18619	10.662	19.5512
8.4255	7485	2.2644	0.00031022	0.23133	10.216	17.6731
9.8229	8143	2.8860	0.00036167	0.26970	9.345	16.2451
11.7135	8802	3.5816	0.00043129	0.32161	8.979	15.0288
15.0015	9760	4.5288	0.00055235	0.41189	9.095	13.5536

Table 7: Second 3030 Propeller Data Settings

Wind tunnel air speed:	2.80	m/s	
Propeller configuration:	3030 Pusher	0.0762	m
Battery (Power Supply Setting):	7.4	volts	

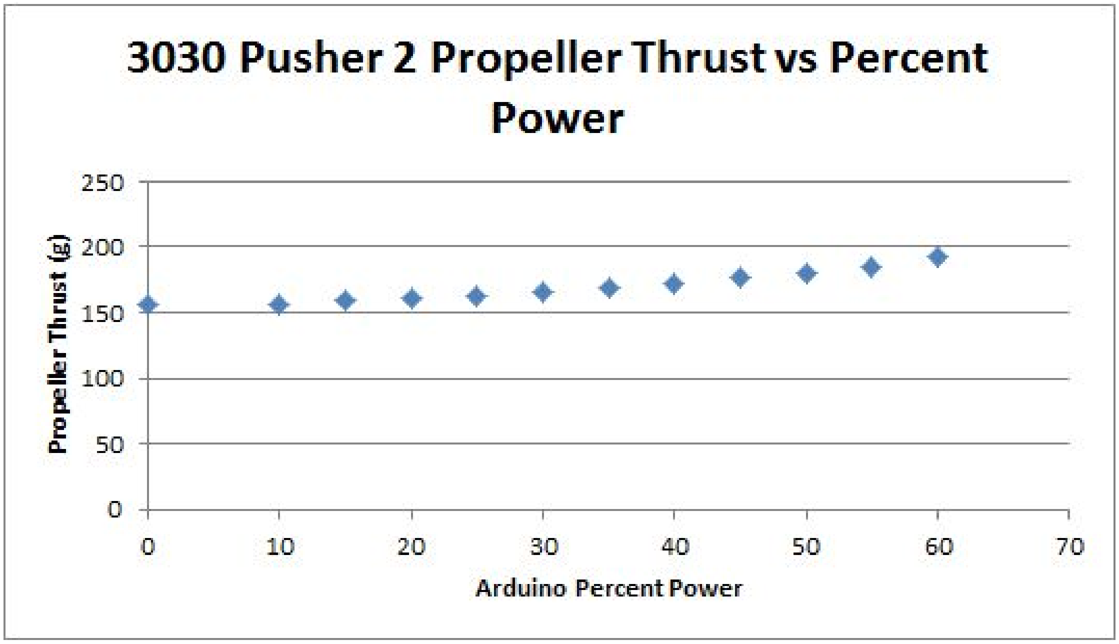

Figure 3: 3030 Second Pusher Propeller Thrust vs Percent Power Graph

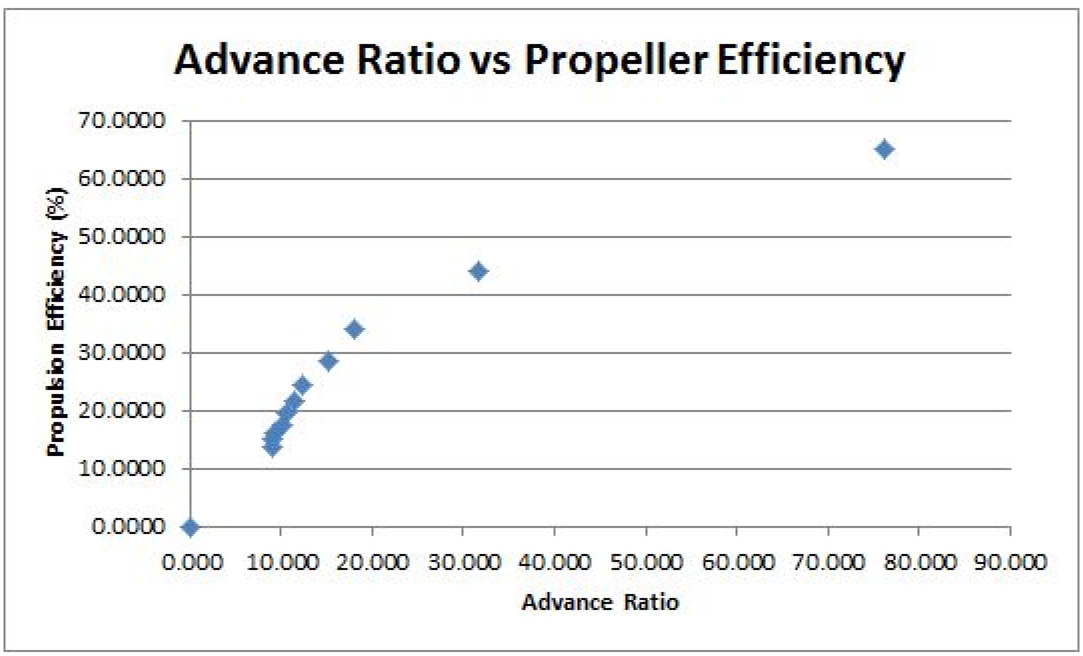

Figure 4: 3030 Second Pusher Propeller Advance Ratio vs Propulsion Efficiency Graph

Table 8: Wind Tunnel Testing Data Puller 2510

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0.06	151.6	0	0
0.15	149.8	2180	10
0.23	149.7	3443	15
0.31	150	4640	20
0.39	150	5800	25
0.47	152	7050	30
0.54	154.5	8263	35
0.55	155	9780	40
0.65	158	10650	45
0.68	160	11800	50
0.7	162	13000	55
0.72	166	14200	60

Table 9: Wind Tunnel Data Analysis Puller 2510

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Horsepower*	*Watts*	*%*	*--*
0.000	0.000	0.000	0.00000000	0.000	0.000	0.000
-0.740	2180.000	0.111	-0.00002821	-0.021	-18.953	75.417
-0.781	3443.000	0.255	-0.00002978	-0.022	-8.698	47.752
-0.658	4640.000	0.459	-0.00002508	-0.019	-4.076	35.433
-0.658	5800.000	0.722	-0.00002508	-0.019	-2.592	28.346
0.164	7050.000	1.043	0.00000627	0.005	0.448	23.320
1.192	8263.000	1.399	0.00004545	0.034	2.423	19.897
1.397	9780.000	1.628	0.00005329	0.040	2.441	16.811
2.630	10650.000	2.165	0.00010031	0.075	3.456	15.438
3.452	11800.000	2.516	0.00013166	0.098	3.902	13.933
4.274	13000.000	2.849	0.00016300	0.122	4.266	12.647
5.918	14200.000	3.197	0.00022570	0.168	5.265	11.578

Table 10: Propeller 2510 Data Settings

Wind tunnel air speed:	2.9	m/s
Propeller configuration:	puller 2510	
Battery (Power Supply Setting):	7.4	volts

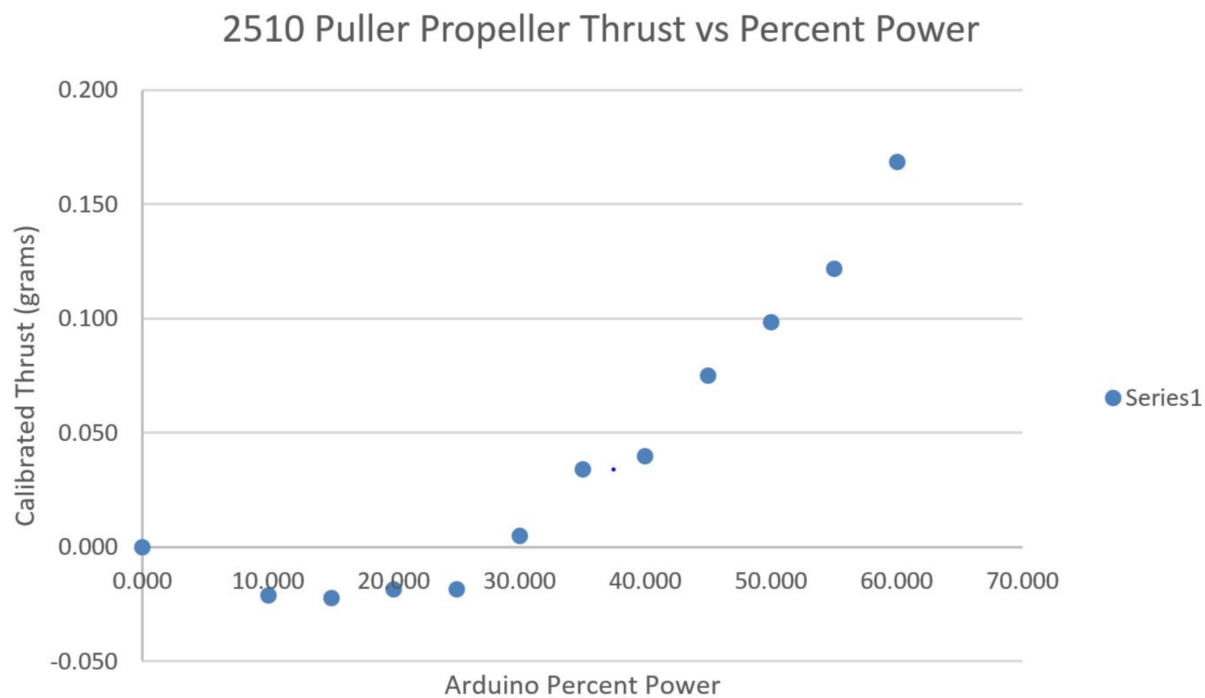

Figure 5: 2510 Puller Propeller Thrust vs Percent Power Graph

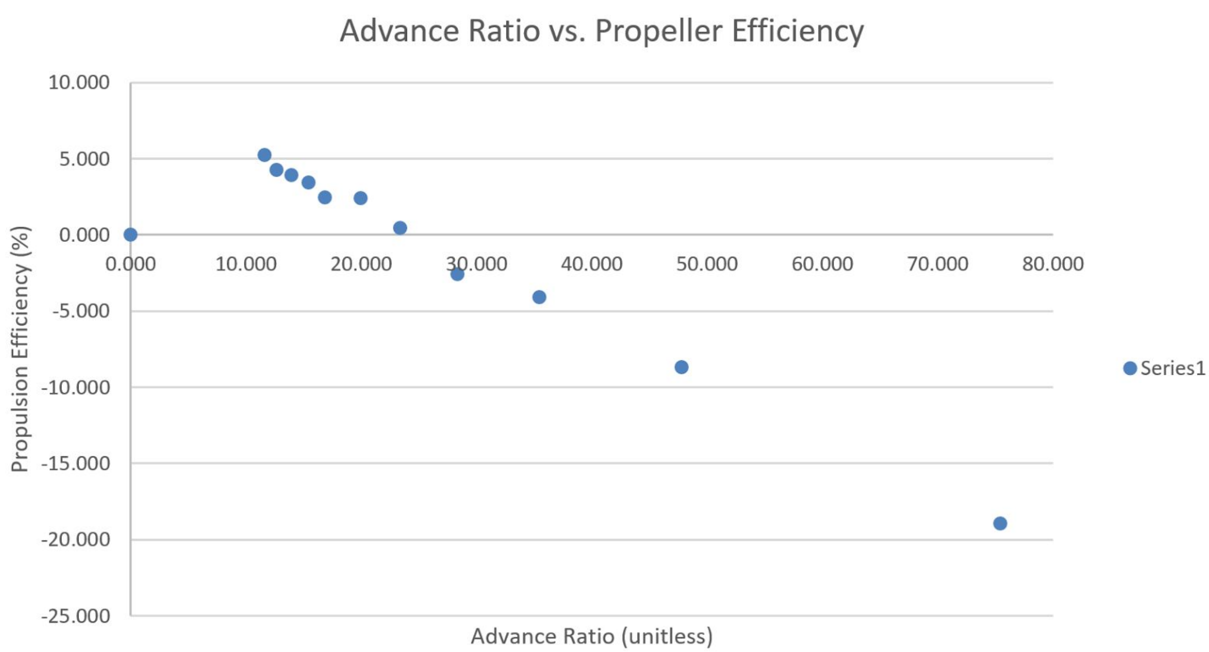

Figure 6: 2510 Puller Propeller Advance Ratio vs. Propeller Efficiency Graph

Melanie Gross-Sample Calculations

The following calculations are for the 3030 Pusher Configuration at 50% arduino power.

Power input:

P_{in}=V*I*($P_{\%}$/100)

P_{in}=7.4 volts* .77 amps*(50/100)

P_{in}=2.849 watts

Power output:

P_{out}=T_c*v

P_{out}=-.2055 g*2.7m/s

P_{out}=-.5548 gm/s* .002205 lbs/g

P_{out}=-.00122 m lbs/s * 3.28 ft/s

P_{out}= -.004 lbs ft/s * 1 s/ 550 lbs ft

P_{out}=-7.26*10^-6 horsepower * 745.7 watts/ 1 horsepower

P_{out}=-.0054 watts

Calibrated Thrust

T_c=.411*(T-T_0)

T_c=.411* (11.2 g – 11.7 g)

T_c=-.2055 g

Advance Ratio

$$J=\frac{v}{\left(\frac{RPM}{60}\right)*D}$$

$$J=\frac{2.7\frac{m}{s}*60s}{\left(\frac{8043}{60}min\right)*.0762\ m}$$

J=15.85

Propulsion Efficiency

$$\eta_{sys}=\frac{P(out)}{P(in)}*100$$

$$\eta_{sys}=\frac{-.0054\ watts}{2.849\ watts}*100$$

η_{sys}=-.1875%

Jessica Hudak - Sample Calculations

The following are sample calculations for the calibrated thrust, the power input, the power output, propulsion efficiency, and advance ratio when the Arduino power setting is 55%:

Calibrated Thrust:

$T_c = (0.411)\ (T - T_0)$
$T_c = (0.411)\ (15.0\ \text{grams} - 11.7\ \text{grams})$
$T_c = (0.411)\ (3.3\ \text{grams})$
$T_c = 1.3563\ \text{grams}$

Power Input:
$P_{in} = (V) * (I) * (P_{\%} / 100)$
$P_{in} = (7.4\ \text{volts}) * (0.86\ \text{amps}) * (55 / 100)$
$P_{in} = 3.5002\ \text{watts}$

Power Output:
$P_{out} = (Tc) * (v)$

First, convert T_c from grams to Newton:
(1.3563 grams) * (0.002205 lbs / 1 gram) = 0.00299 lbs
(0.00299 lbs) / (4.5 N / 1 lbs) = 0.013455 N
So:

$P_{out} = (0.013455\ N) * (2.7\ m/s)$
$P_{out} = 0.363285\ \text{watts}$

Propulsion Efficiency:
$= (P_{out} / P_{in}) * (100)$
= (.363285 watts / 3.5002 watts) * (100)
= (.10379) * (100)
= 10.379 %

Advance Ratio:
J = [v / ([RPM / 60] * D)]

First, convert the propeller diameter from inches to meters:
(3 in) * (2.54 cm / 1 in) * (1 m / 100 cm) = 0.0762 m
So:

J = [(2.7 m/s) / ([8682 / 60] * 0.0762 m)]
J = [(2.7) / ([144.7] * 0.0762)]
J = (2.7) / (11.0261)
J = 0.24487

Katie Gonsoulin - Sample Calculations

The following calculations are at 15% power:

1) Power input:

Pin = V * I * (P% / 100)

Pin = 7.4 volts * 0.09 amps * (15%/100)

Pin = 0.0999 watts

2) Power output:

Pout = Tc * v

Pout = (11.7g * (0.002205lb / 1g)) * (2.7m/s * (3.28ft/s / 1m/s))

Pout = 4.154*10^-4 horsepower

Pout = 4.154*10^-4 horsepower * (745.7 watts / 1 horsepower)

Pout = 0.3098 watts

3) Calibrated thrust:

Tc = 0.411 * (T -T0)

Tc = 0.411 * (9.4 g - 11.7)

Tc = -0.9453 g

4) Advance ratio:

J = (v*60) / ((RPM / 60) * D)

J = (2.7m/s * 60) / ((3035 RPM / 60) *0.0762 m

J = 42.0293

5) Propulsion efficiency:

Efficiency = (Pout / Pin) * 100

Efficiency = (-0.0250 watts / 0.0999 watts) * 100

Efficiency = -25.0525 %

Jennifer Bertrand- Sample Calculations

The following calculations are when the Arduino power setting is 50% Pusher 3030.

Power Input:

P_{in}=V*I*($P_{\%}$/100)

P_{in}=(7.4V)*(0.77amps)*(50%/100)

P_{in}=2.849watts

Power Output:

P_{out}=T_c*v

P_{out}=(-0.2055g*(0.002205lbs/1g))*(2.7m/s*(3.28ft/s/1m/s))*(1hp/550lbs*ft/s)*(745.7watts/1hp)

P_{out}=-0.00544watts

Calibrated Thrust:

T_c=0.411*(T-T_0)

T_c=0.411*(11.2g-11.7g)

T_c=-0.2055g

Advance Ratio:

J=v/((RPM/60)*D)

$J=(2.7m/s*60s/min)/((8043/60min)*0.0762m)$

$J=15.8596$

Propulsion Efficiency:

$n_{sys}=(P_{out}/P_{in})*100\%$

$n_{sys}=(-0.00544watts/2.849watts)*100\%$

$n_{sys}=-0.1909\%$

Team Meeting Notes

Date: 29-Jan-2017

Time: 3:04pm (Face-to-Face)

Members Present: Jessica Hudak, Melanie Gross, Jennifer Bertrand, Katie Gonsoulin

Topics Discussed: Lab 2 Progress Report

Objective: Today's goal was to assign parts for progress report, update the project portfolio website and update the team calendar.

To do/Action Items:

-Progress Report-(JH, JB, MG, KG)

-Project Portfolio: (MG, JB, KG, JH)

-Team Calendar: (MG)

Decisions:

-Decide who will complete which aspects of the progress report and project portfolio

Reflections:

-This week our AEV design was a little off balance, we will continue to work on the design for the upcoming weeks.

Arduino Code

```
 // Run all motors at a constant speed of 25% power for 2 seconds
motorSpeed(4,25);
goFor(2);

//Run all motors at a constant speed of 20% and using the goToAbsolutePosition function travel a total distance of 16 feet (from the starting point
motorSpeed(4,20);
goToAbsolutePosition(394);

//Reverse motors
reverse(4);

// Run all motors at a constant speed of 30% power for 1.5 seconds
```

```
motorSpeed(4,30);
goFor(1.5);

//Brake all motors
brake(4);

//Save the program as ExternalSensorsOutside
```

Pictures

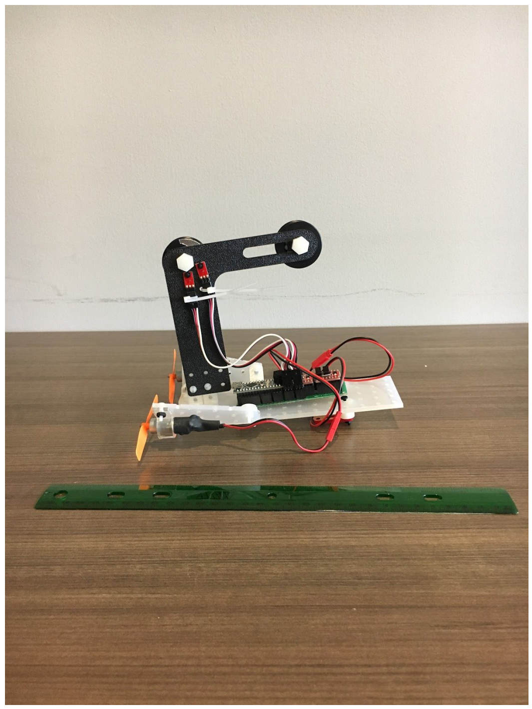

Figure 7:Side View of AEV

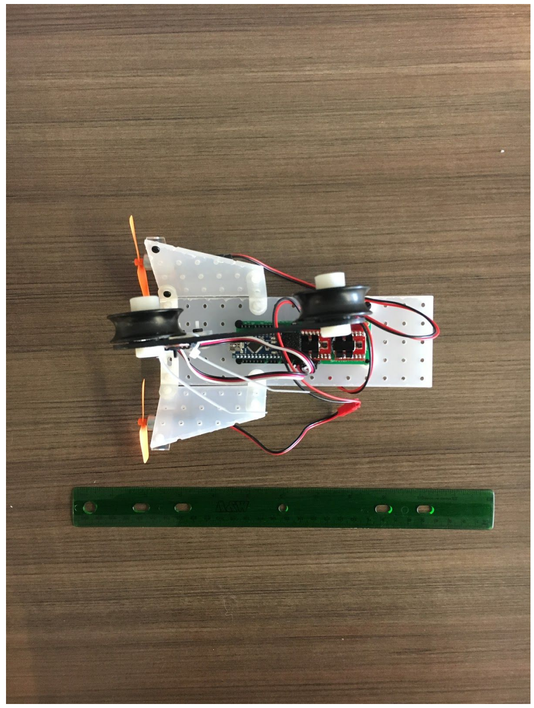

Figure 8: Top View of AEV