To: Dr Janiszewska

From: Ian Claggett, Ed Doerring, Stuart Fanko (Group Jasper)

Subject: ENGR 1182.01

Date: February 25, 2021

Introduction:

In this lab, we test the efficiency of our propellers and motors to find the right amount of power to get the most power output with the least amount of power used. We find out the exact numbers for each propeller type as well as the efficiency of each blade both going forward and in reverse. These test will help the team decide which blade to use and what power settings to set the code to for running the AEV.

Progress report:

As seen in the graphs, it was found that the EF-3 puller blade was the most efficient blade used in the testing. It showed the largest amount of power output at any level of power input meaning that it is most optimal for any blade speed though it runs most efficiently at top speed and power input. This information gained from the lab will allow for the best propeller to be chosen for most optimal design. It will affect the power consumption of the AEV and thus affect the cost of running the AEV.

This propeller blade was not chosen for the design and changing to this blade would greatly enhance the build. A slight redesign would be needed but the gained power and efficiency would greatly improve the chosen design seeing as the three bladed puller propeller is nearly two times more powerful than the two bladed propeller currently configured on the AEV.

Another finding of the lab was the difference of the pusher and puller propellers. The blades are designed to be able to be used both to push and pull the AEV. Having said that it was found that this is not efficient at all. Using the blades in reverse as pusher propellers used large amounts of energy input with very little output. This would mean that going in reverse will not only be slower but will take more charge off the battery as it works harder to push the AEV across the track.

The EF-3 was again one of the best options for a pushing blade and was the most efficient at top speed when compared to the other pusher propellers, though it was beaten out at lower power levels. Seeing as the motors will be used at peak performance the EF-3 blade seems to be the best option all around and changing the design to accommodate it would be very fruitful for the efficiency of the AEv.

Conclusion:

After completing the lab and compiling the data, it was obvious which propeller blade set up was most optimal for the most efficient design of the AEV. The EF-3 blade proved to be the most effective and efficient out of all the blade configurations showing that a third blade greatly increases power output while still using the same power input. It was found that it would be most optimal if the design was remade to include these EF-3 blade propellers as it would greatly benefit the performance of the AEV.

Appendix:

Propeller Type EP-3030:

Propeller Type EP-3030

Wind tunnel air speed:	3.5	m/s	
Propeller configuration:	pusher		
Battery (Power Supply Setting):	7.4	volts	

Wind tunnel air speed:	3.5		
Propeller configuration:	puller		
Battery (Power Supply Setting):	7.4		

Table 1: Wind Tunnel Testing Data

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160		0
0.29	162	2574	15
0.39	164	3413	20
0.48	167	4191	25
0.58	170	4970	30
0.68	174	5677	35
0.77	178	6307	40
0.84	181.5	7111	45
0.95	186	7724	50
1.03	188	8383	55
1.09	189	9600	60

Table 1: Wind Tunnel Testing Data

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160		0
0.28	162	2100	15
0.38	164.2	2335	20
0.48	167	2934	25
0.59	171.7	3652	30
0.7	177	4311	35
0.82	182	4970	40
0.92	187	5688	45
1.23	196	7399	50
1.13	195	8411	55
1.23	197	9100	60

Propeller Type EP-3030

Table 2: Wind Tunnel Data Analysis -- Pusher

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
0.82	2574	0.32	0.03	0.00	8.76	0.74
1.64	3413	0.58	0.06	0.00	9.77	0.56
2.88	4191	0.89	0.10	0.00	11.11	0.46
4.11	4970	1.29	0.14	0.00	10.95	0.38
5.75	5677	1.76	0.20	0.00	11.21	0.34
7.40	6307	2.28	0.25	0.00	11.13	0.30
8.84	7111	2.80	0.30	0.00	10.84	0.27
10.69	7724	3.52	0.37	0.00	10.43	0.25
11.51	8383	4.19	0.39	0.00	9.42	0.23
11.92	9600	4.84	0.41	0.00	8.45	0.20

Table 2: Wind Tunnel Data Analysis -- Puller

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
0.82	2100	0.31	0.03	0.00	9.07	0.91
1.73	2335	0.56	0.06	0.00	10.53	0.82
2.88	2934	0.89	0.10	0.00	11.11	0.65
4.81	3652	1.31	0.16	0.00	12.59	0.52
6.99	4311	1.81	0.24	0.00	13.22	0.44
9.04	4970	2.43	0.31	0.00	12.78	0.38
11.10	5688	3.06	0.38	0.00	12.42	0.34
14.80	7399	4.55	0.51	0.00	11.15	0.26
14.39	8411	4.60	0.49	0.00	10.73	0.23
15.21	9100	5.46	0.52	0.00	9.55	0.21

Propeller EP-3020

Propeller Type EP-3020

Wind tunnel air speed:	3.5	m/s	Wind tunnel air speed:	3.5
Propeller configuration:	Pusher		Propeller configuration:	puller
Battery (Power Supply Setting):	7.4	volts	Battery (Power Supply Setting):	7.4

Table 1: Wind Tunnel Testing Data

Table 1: Wind Tunnel Testing Data

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	grams	RPM	%
0	172.3		0
0.28	173	3113	15
0.37	174.5	4071	20
0.46	177.5	4970	25
0.55	182	5928	30
0.64	185	6826	35
0.73	188	7724	40
0.8	191	8562	45
0.87	193	9341	50
0.93	194	10119	55
0.99	197	10838	60

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	grams	RPM	%
0	161		0
0.28	162	2095	15
0.38	163.4	2754	20
0.48	166.3	3592	25
0.59	171	4491	30
0.7	175	5389	35
0.82	181	6227	40
0.92	185	7005	45
1.23	194.5	7844	50
1.13	194.9	8622	55
1.23	196	9700	60

Propeller Type EP-3020

Table 2: Wind Tunnel Data Analysis -- Pusher

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	RPM	Watts	Watts	Horsepower	%	--
0.288	3113	0.311	0.010	0.000	3.175	0.613
0.904	4071	0.548	0.031	0.000	5.664	0.469
2.137	4970	0.851	0.073	0.000	8.614	0.384
3.987	5928	1.221	0.137	0.000	11.199	0.322
5.220	6826	1.658	0.179	0.000	10.801	0.280
6.453	7724	2.161	0.221	0.000	10.243	0.247
7.686	8562	2.664	0.264	0.000	9.896	0.223
8.508	9341	3.219	0.292	0.000	9.065	0.204
8.919	10119	3.785	0.306	0.000	8.082	0.189

10.152	10838	4.396	0.348	0.000	7.922	0.176

Table 2: Wind Tunnel Data Analysis -- Puller

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
0.411	2095	0.311	0.014	0.000	4.536	0.911
0.986	2754	0.562	0.034	0.000	6.016	0.693
2.178	3592	0.888	0.075	0.000	8.414	0.531
4.110	4491	1.310	0.141	0.000	10.763	0.425
5.754	5389	1.813	0.197	0.000	10.886	0.354
8.220	6227	2.427	0.282	0.000	11.616	0.307
9.864	7005	3.064	0.338	0.000	11.044	0.273
13.769	7844	4.551	0.472	0.001	10.377	0.243
13.933	8622	4.599	0.478	0.001	10.391	0.221
14.385	9700	5.461	0.493	0.001	9.035	0.197

Propeller EF- 3 bladed

Propeller Type EF - 3 Bladed

Wind tunnel air speed:	3.5	m/s	Wind tunnel air speed:	3.5
Propeller configuration:	Pusher		Propeller configuration:	Puller
Battery (Power Supply Setting):	7.4	volts	Battery (Power Supply Setting):	7.4

Table 1: Wind Tunnel Testing Data

Table 1: Wind Tunnel Testing Data

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160.4		0
0.27	161	2295	15
0.37	164	2996	20
0.47	167	3696	25
0.58	171	4397	30
0.68	177	5098	35
0.8	182.1	5797	40
0.91	187	6498	45
1.01	199	7198	50
1.13	200	7899	55
1.22	204.6	8599	60

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	166.9		0
0.28	169	2700	15
0.38	172.2	3524	20
0.48	176.9	4348	25
0.59	182.7	5172	30
0.7	188.9	5996	35
0.82	196.6	6820	40
0.92	203.4	7644	45
1.23	211.2	8468	50
1.13	219.2	9292	55
1.23	227.1	10117	60

Propeller Type 3- bladed

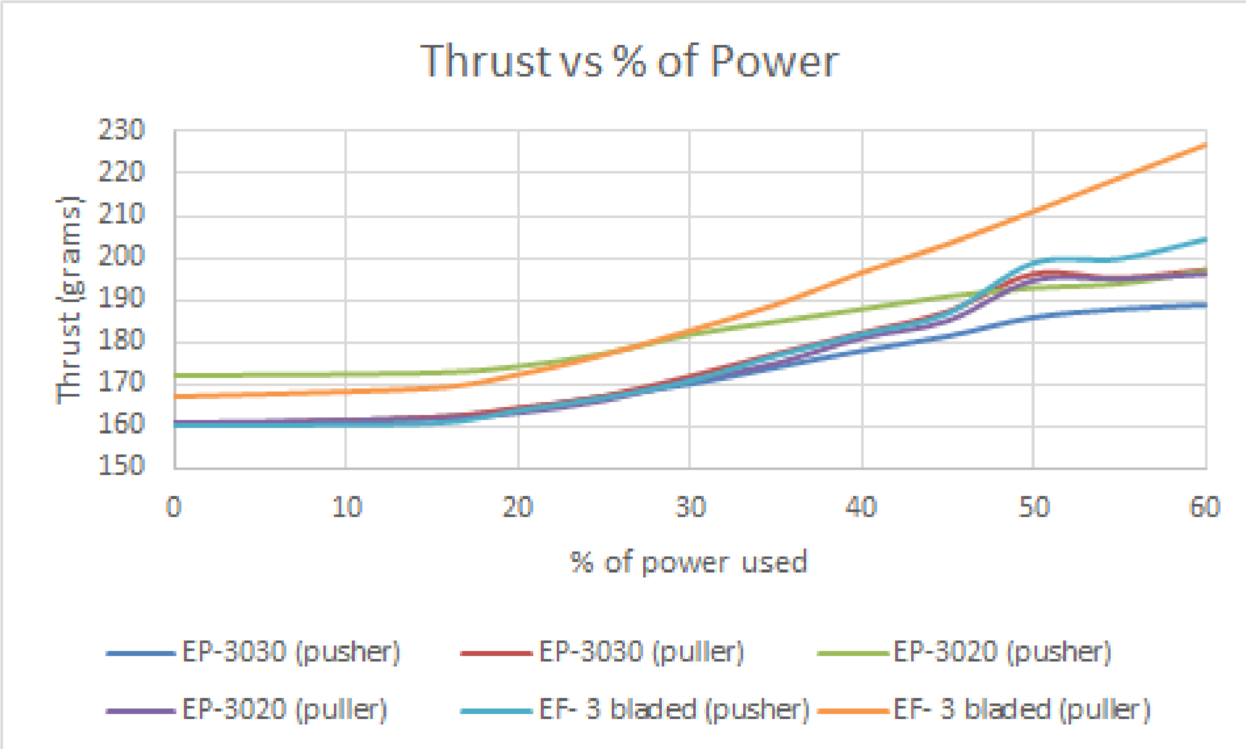
Table 2: Wind Tunnel Data Analysis -- Pusher

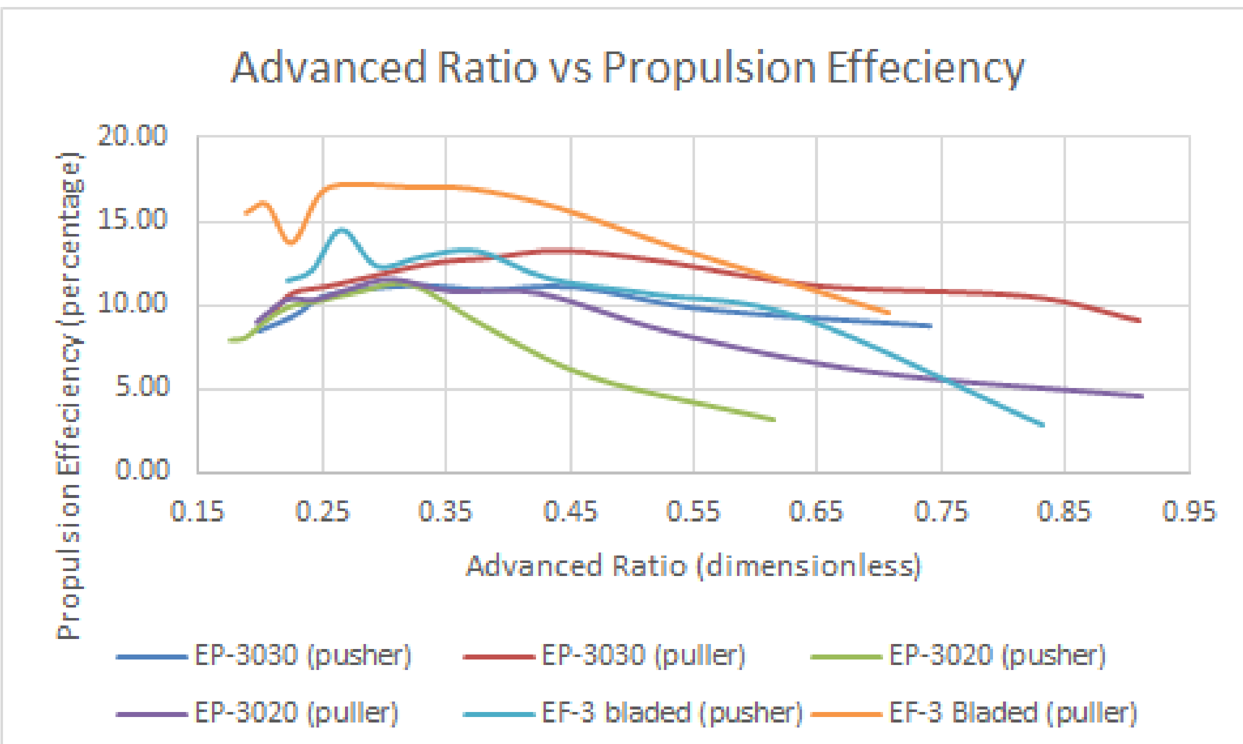
Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
0.247	2295	0.300	0.008	0.000	2.822	0.832
1.480	2996	0.548	0.051	0.000	9.268	0.637
2.713	3696	0.870	0.093	0.000	10.701	0.517
4.357	4397	1.288	0.149	0.000	11.605	0.434
6.823	5098	1.761	0.234	0.000	13.287	0.374
8.919	5797	2.368	0.306	0.000	12.919	0.329

10.933	6498	3.030	0.375	0.001	12.375	0.294
15.865	7198	3.737	0.544	0.001	14.561	0.265
16.276	7899	4.599	0.558	0.001	12.138	0.242
18.166	8599	5.417	0.623	0.001	11.503	0.222

Table 2: Wind Tunnel Data Analysis -- Puller/Tractor

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
0.863	2700	0.311	0.030	0.000	9.525	0.707
2.178	3524	0.562	0.075	0.000	13.285	0.542
4.110	4348	0.888	0.141	0.000	15.875	0.439
6.494	5172	1.310	0.223	0.000	17.005	0.369
9.042	5996	1.813	0.310	0.000	17.106	0.318
12.207	6820	2.427	0.419	0.001	17.250	0.280
15.002	7644	3.064	0.515	0.001	16.796	0.250
18.207	8468	4.551	0.625	0.001	13.722	0.225
21.495	9292	4.599	0.737	0.001	16.031	0.205
24.742	10117	5.461	0.849	0.001	15.540	0.189


Thrust vs % of Power
Thrust (grams)
230
220
210
200
190
180
170
160
150
0
10
20
30
40
50
60
% of power used
EP-3030 (pusher)
EP-3030 (puller)
EP-3020 (pusher)
EP-3020 (puller)
EF- 3 bladed (pusher)
EF- 3 bladed (puller)


Advanced Ratio vs Propulsion Effeciency
Propulsion Effeciency (percentage)
20.00
15.00
10.00
5.00
0.00
0.15
0.25
0.35
0.45
0.55
0.65
0.75
0.85
0.95
Advanced Ratio (dimensionless)
EP-3030 (pusher)
EP-3030 (puller)
EP-3020 (pusher)
EP-3020 (puller)
EF-3 bladed (pusher)
EF-3 Bladed (puller)

Progress Report

Write a Progress Report, be sure to briefly address the following questions.

- An Excel spreadsheet with the correct data is provided for you, you are required to reduce all data and calculate an error in your measurements. Calculate thrust and efficiency for the three propeller types both pusher and puller configuration, using the provided equations in the manual.
- Provide the following figures and tables, remember to describe them:
  - Tables containing Wind Tunnel Data with appropriate labeling and indicated propeller and motor configuration in the appendix of the report.
  - Plots of Thrust (Grams) vs. % power and Propulsion Efficiency vs. Advance Ratio for all three propeller type on one plot (there should be 6 lines on the plot, since you will have pusher and puller configurations).
- Explain how this lab can aid in the strategy and design. Refer to figures and tables. Justify the choice of the propeller based on the data and the design, if you are not using a propeller to drive the system, explain why you chose that and how the data can still be useful.
- Make sure that you explain the difference in the pusher and puller configurations and why obtaining both data types are important.
- What motorSpeed would you need to use approximately to get the maximum efficiency for the pusher and puller configuration of the propeller type you selected.
- ***Individually:*** Sample calculations for power input and output, calibrated thrust, advance ratio, and propulsion efficiency for a single point. (Do this on a separate Microsoft Word page and attached in the Appendix with each individual team member's name).

Lab 5: System Analysis 1 Grading Rubric Progress Report		
Report		30
Writing Total	Spelling/Grammar Language Usage	20
Total		50

Instructor signature ______________________________

Work division for this summary

Student Name:	Description of work
________________	________________
________________	________________
________________	________________
________________	________________