# Preliminary Design Report

**Submitted To**

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**Abstract**

The purpose of the lab was to design a vehicle to aid the rebels in transporting R2D2's across multiple locations. The vehicle would have to be both lightweight and energy efficient in order for the mission to function at an optimal level. The vehicle also has to be able to move on multiple terrains due to there being many different planets that the vehicle will be operated on.

The group took many insights away from the results of their experiments. The group decided that the ep - 3030 pull propeller is the most efficient in terms of thrust and efficiency. The 3030 pull had a thrust value of 18.49 grams which was much higher than the other types of propellers. Also, the group decided that the AEV should be very aerodynamic in order to ensure that a minimal amount of energy would be needed to make the vehicle move from one location to another. Multiple lab tests also determined that the AEV used the least amount of energy while it was coasting. This is due to the fact that when the AEV is coasting, the motors are turned off which leads to a much greater energy efficiency rating. The AEV will also have an exterior shell to ensure that it is aerodynamic no matter what planet or terrain that it is being used on. The vehicles code is strongly focused on using a maximum amount of coasting in order to keep the AEV running efficiently and correctly. The only problem that was encountered while using the coasting method was that at times the AEV would barely miss its target location. To combat this, a more precise code will be used in the near future. Finally, the AEV is very cost efficient. The vehicle uses the bare minimum in terms of parts so it will be able to be purchased and built in a very cost and time efficient manner.

With all of the data and results taken into consideration it is highly recommended that the rebels use this group's AEV. The AEV is very cost and energy efficient which will allow for rapid use and production. Also, the vehicle can last on many different terrains due to its exterior shell that will help it stay aerodynamic no matter what location it is being used at.

**Introduction**

The lab excercises were designed to help the group complete the mission concept. Each lab gave the team different tools to create, test, and compare vehicles in order to create the most efficient AEV possible. The first few labs familiarized the team with coding and basic Arduino function, and the next few were focused on designing and comparing new AEV models. Now the labs are focused on testing the AEV and refining the code and making slight changes to the design to finish the mission.

The main purpose of the lab is to create a vehicle for the rebels that is both cost and energy efficient. The vehicle must be able to run on multiple terrains as well due to there being many different surfaces that the AEV will need to traverse.

**Experimental Methodology**

Lab 1 was focused on getting used to and testing the Arduino. Important takeaways were knowledge of the basic commands necessary to run the motors. Lab 2 was focused on becoming familiar with the Arduino code and the AEV sketchbook commands. Important takeaways were the reflectance sensor tests, and information for determining the distance traveled by the AEV. In Lab 3, the group built the basic AEV and intended to test the design with basic code. The AEV ran to the gate and stopped at the first sensor. The lab gave the group an opportunity to see an AEV in action and gave ideas for what could be improved. In Lab 4, the group created concept designs for the AEV. Each member created a design, two of which are shown in appendix B, the Tough Guy model, Figure 8, and the Barack-o-flock-o-flame model, Figure 9. These designs would later be compared and ranked according to team decided parameters. Lab 5 taught to team how to gather data from the AEV. This allows the team to empirically compare the energy usage and efficiency. The basic AEV design and code were used to find a baseline to which further models can be related to. Lab 6 gave the team ways to rate proposed designs in the form of a concept screening matrix. From this lab, the team picked the design areas that were found to be the most important and mixed preliminary models to create the proposed final design, the sunfish (Appendix B Figure 4).

**Results**

From the various data that was obtained the group decided that the ep-3030 pull propeller would be used in order to make the AEV run in the most efficient manner possible. The 3030 pull propeller exhibited the highest thrust with a value of 18.49 grams. The group also determined that if the AEV was able to coast to its desired locations then it would a lot more energy efficient due to the fact that the motors would not be active for most of the time that the vehicle was running. Finally, the group agreed that a lightweight design with an aerodynamic shell would be a huge aid in allowing the AEV to run efficiently. A sunfish design was chosen for the shell because it would allow the vehicle to encounter the least amount of wind resistance while gliding around the track.

The team was unable to get the data from the AEV run. There is an issue with the sensor that determines the position of the AEV at a given time, and the vehicle continued to run indefinitely without stopping. Because of this, data for the run was impossible to record as the AEV would not complete the code to any satisfactory means. For this reason, the data analyzed will be from an earlier lab.

There are 4 phases demonstrated in figures 1-3. An initial power surge is related to the motorSpeed command at 25% power. The AEV then coasts, and is shown in the graphs by a relatively flat line for about 2 seconds. A second surge of power is when the AEV reverses itself and slows down. Last, the line graph drops to zero as the power is cut off using a break function. This graph is important as it shows just how power efficient the vehicle is in a visual setting.

The first error encountered by the group was a broken motor. The motor would not run regardless of which port it was connected to or which code was used. This error was resolved by getting a new motor which worked properly. The next error the team faced was a bad Arduino. The code would not upload to the AEV, and after a long period of trial and error, a new Arduino was obtained and the drivers on the computer were updated, which solved the problem. The current problem facing the group is a reflectance sensor that does not consistently record data. A possible fix for this problem would be to swap out the poor sensor with the second sensor included in the AEV kit. If this does not work, the attachment point will be reviewed and possibly changed to better fit the sensor. These errors caused the schedule to be pushed back. Also, since the AEV did not stop at the gate, it could not complete the entire run, and therefore the data could not be collected from the new AEV.

The new AEV is much lighter than the base model, which should in theory cause it to use less energy. This was shown in practice when using the same code sent the AEV much further down the track at a much faster rate, so the new AEV used the same energy to better effect. This is due to the weight, which reduces the power needed to move further and faster down the monorail track. While not a huge decrease in material used, it is significant enough to substantially improve the AEV's efficiency.

**Recommendations and Conclusion**

The team recommends that the rebels go through with using the designed AEV. There is currently not a lot of data to support this decision, but this is most likely due to the sensor not working properly. Once the sensor issue is fixed the vehicle will run a lot more efficiently. In the few runs that the sensor has worked, the vehicle has met all of the requirements and been very energy and cost efficient.

During the time of the project, the team has learned how to code using the Arduino software, as well as how to use Solidworks and apply that knowledge to building the physical AEV. The team has also become adept at problem solving and working forward without giving up. These compare to the lab objectives by solving the issues posed in each lab within an allotted amount of time. The results also reflect this by showing in concrete evidence that the team is progressing forward.

**Concepts**

The group was focused on speed and efficiency when creating their AEV prototypes. In order, to achieve this the team made two prototypes, both using limited materials. The first prototype (Appendix B Figure 6) was made by materials already given to the group. The arm was L shape causing the balance to be shifted forward. To counteract this the battery and Arduino were placed on the other end of the AEV. The newer AEV (Appendix B Figure 4) was made with a laser cut arm that has a T shape causing the mass to be more centered. Also, by only using the one arm and no other pieces, the AEV is much more durable. So the team chose the "Sunfish design" because it fit most of their criteria. The weight and durability of this design proved to be most effective (Figure 10).

The team looked at their original designs to come together to make their new prototype. Originally, the team had hoped to put a shell around their AEV to be more aerodynamic, however, this was scratched when the team considered the added weight. The team decided to keep the idea of having a more vertically shaped AEV so that they could get all of the pieces on the single arm.

**Observations**

One design worked while the other is a current work in progress. The first AEV design tested ran rather smoothly, but it consumed a relatively large amount of energy (Appendix B Figures 1 & 2). It was larger, bulky, and moved slowly; requiring about thirty-percent engine power to move on average. The new design requires about twenty-percent engine power to move at the same speed, a significant increase in efficiency. However, it does not run reliably. There is something wrong with the sensors.

Unfortunately, the data was unable to be recorded recently on the preformance of the AEV due to technical issues. However, this lab enlightened the team on issues that need fixed in the design of the vehicle. Luckily, when the AEV does run correctly, it seems to run smoothly and only need a few touch-ups in terms of the coding.

**Conclusion**

Through labs and private meetings, the team was able to determine the proper materials to get the most efficient, light weight, and balanced AEV they could. The team ran the vehicle on the actual track to come up with a code that could be easily adjusted for the AEV's different needs. These trials and errors have caused the team to collaborate and come up with a final design and code for their AEV.

**Appendix A**

| Task | Teammates | Start Date | Due Date | Time Needed | Percentage Completed |
|---|---|---|---|---|---|
| **Preliminary Design Report** | All | 3/23/2017 | 3/24/2017 | 2 Hours | 100% |
| **Correcting AEV code** | Madison Hudak (Coder) | 3/24/2017 | 4/17/2017 | 55 minutes | 45% |
| **Fix sensor** | Collin Barack (Builder) | 3/24/2017 | 4/17/2017 | 55 minutes | ?% |
| **CDR** | All | 4/1/2017 | 4/19/2017 | 18 days | 0% |
| **Project Portfolio** | All | 4/1/2017 | 4/21/2017 | 20 days | 0% |
| **Showcase** | All | 4/1/2017 | 4/18/2017 | 17 days | 0% |

**Appendix B**

Figure 1: Excel generated graph of Supplied Power vs. Time.

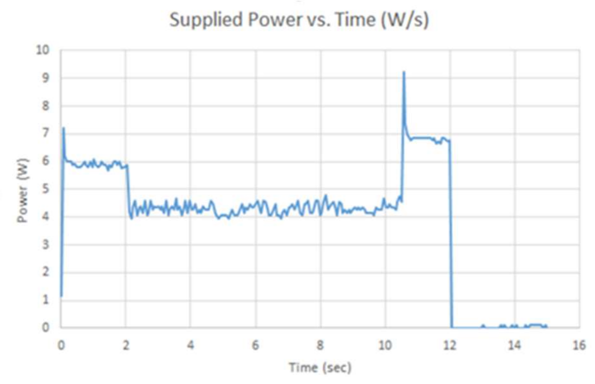



Figure 2: AEV data analysis generated graph of Supplied Power vs. Time.

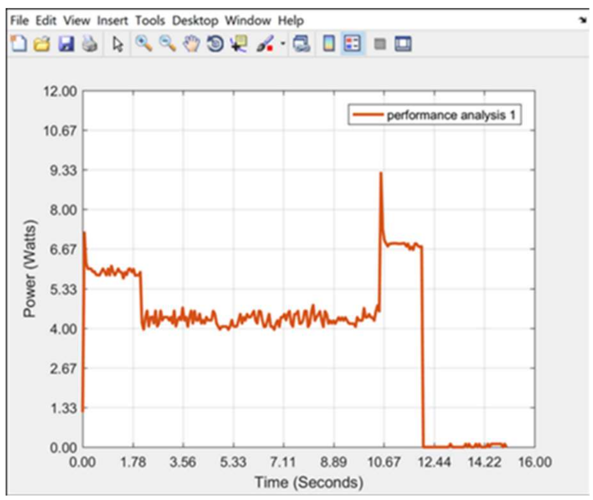



Figure 3: AEV Data Analysis generated graph of Supplied Power versus Distance.

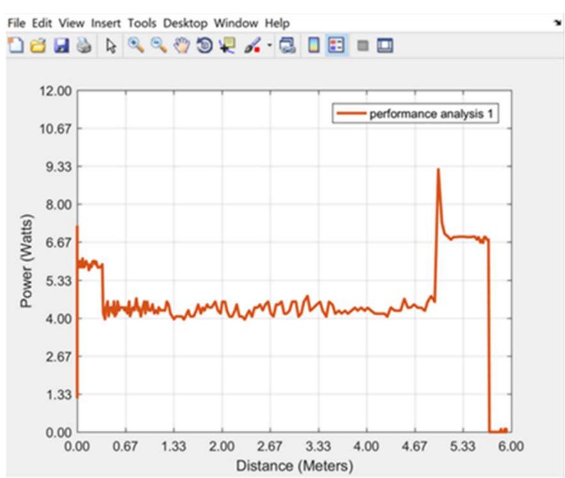


Figure 4: Sunfish AEV design

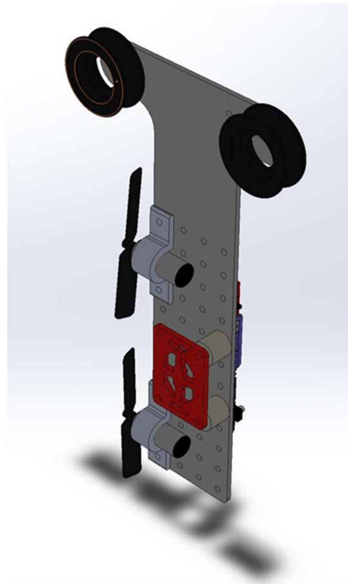
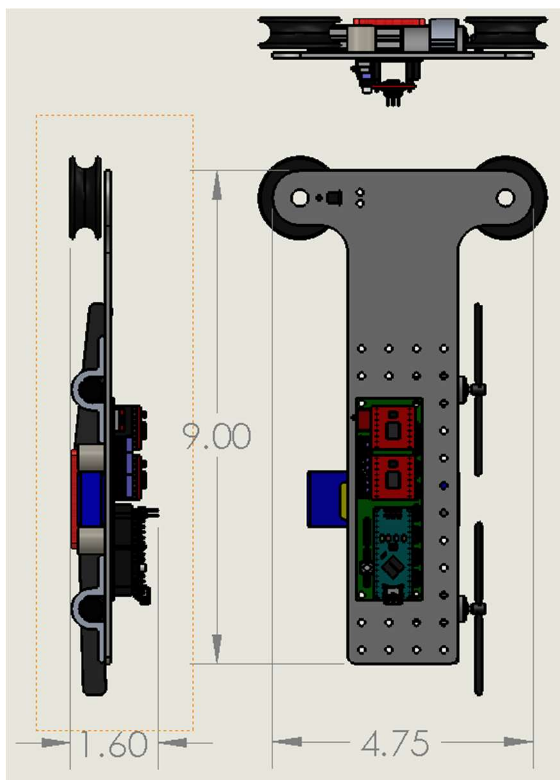


Figure 5: Sunfish AEV orthographic drawing




Approximate weight: 0.25 lbs.

Cost: $153

Materials:

| ITEM NO. | PART NUMBER | QTY. |
| --- | --- | --- |
| 1 | proto Support Arm 2 2 Sensor Holes | 1 |
| 2 | AEV Arduino Assembly | 1 |
| 3 | Battery Pack | 1 |
| 4 | Prop 3inch | 2 |
| 5 | AEV Motor | 2 |
| 6 | Motor Mount Clip Aluminum | 2 |
| 7 | Battery Spacer | 2 |
| 8 | Battery Pack Clamp Plate Narrow | 1 |
| 9 | Housing | 2 |

Figure 6: Remastered AEV design right

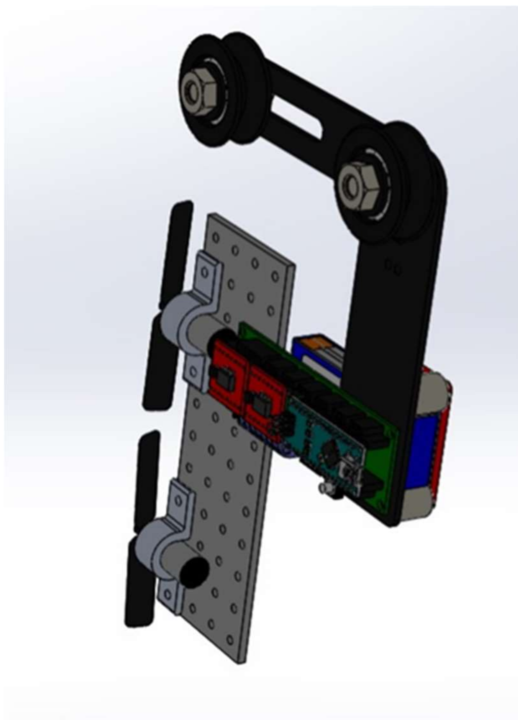


Figure 7: Remastered AEV design left

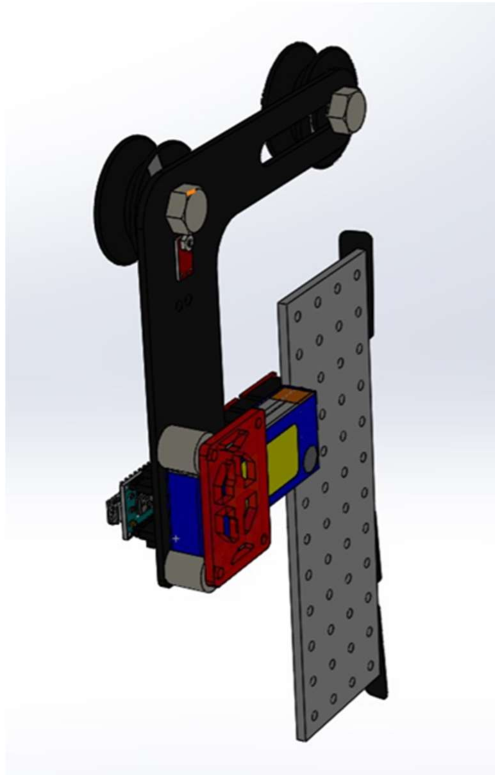
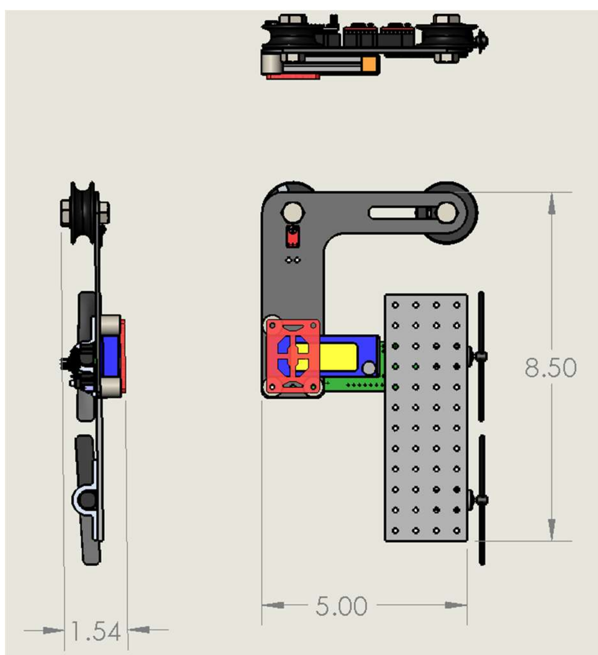


Figure 7: Remastered AEV orthographic drawing




Approximate weight: 0.293 lbs

Cost: $160

Materials:

| ITEM NO. | PART NUMBER | QTY. |
|---|---|---|
| 1 | Motor Mount Clip Aluminum | 2 |
| 2 | AEV Motor | 2 |
| 3 | Support Arm 2 ABS | 1 |
| 4 | Pulley Assembly w-reflective tape | 1 |
| 5 | Pulley Assembly | 1 |
| 6 | Battery Pack Clamp Plate Narrow | 1 |
| 7 | Battery Pack | 1 |
| 8 | Battery Spacer | 3 |
| 9 | Rotation Sensor Board | 1 |
| 10 | hex bolt_ai | 2 |
| 11 | machine screw nut hex_ai | 2 |
| 12 | machine screw nut hex_ai | 1 |
| 13 | flat head 100 screw_ai | 1 |
| 14 | AEV Arduino Assembly | 1 |
| 15 | Medium Rectangle | 1 |
| 16 | Prop 3inch | 2 |

Figure 8: Sunfish Origins ™ Orthographic drawing

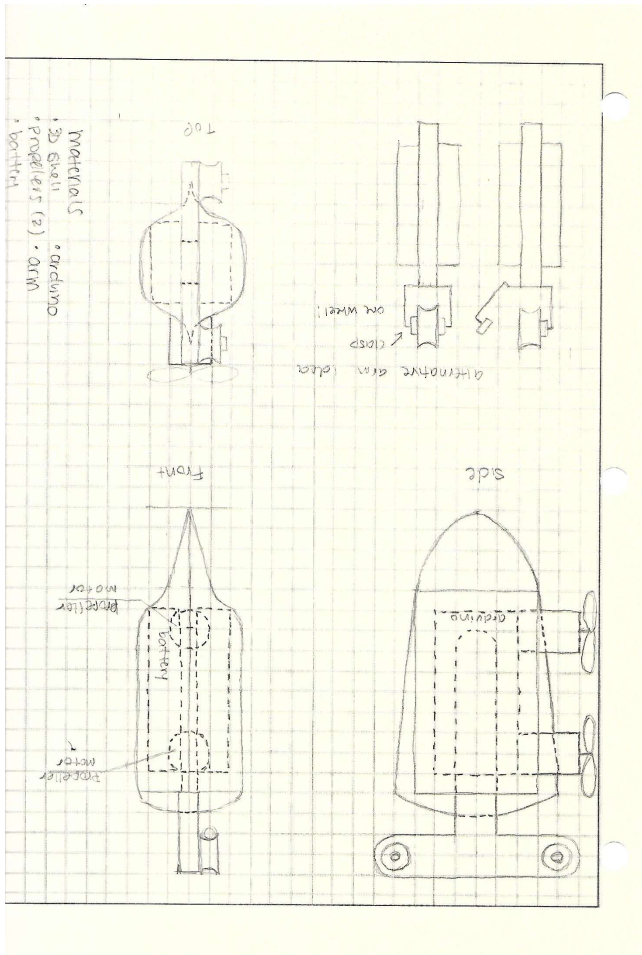



Figure 9: Barack-o-flock-o-flame orthographic drawing

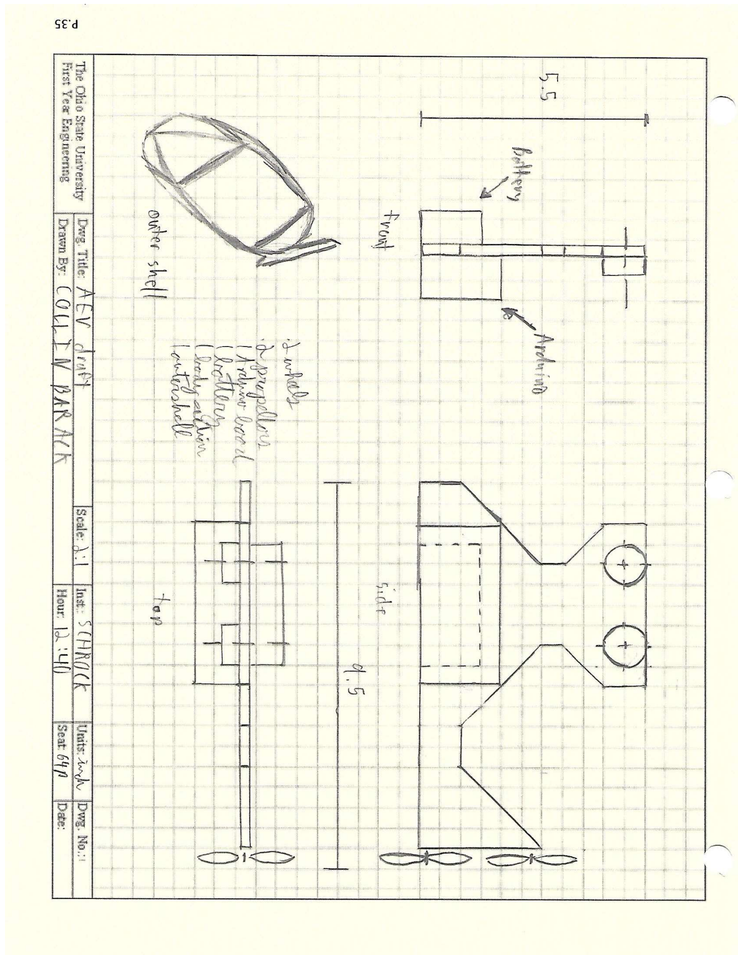



Figure 10: Concept Screening Matrix

| | Reference A | Liz-dog | Toughy | Barack-o-flock-flame | god |
|---|---|---|---|---|---|
| Stays on the track | 0 | 0 | 0 | 0 | 0 |
| Weight | o | - | + | + | 0 |
| Ability to carry trailer | o | + | 0 | 0 | 0 |
| Cost | o | 0 | + | + | 0 |
| Aesthetic | 0 | + | + | - | 0 |
| Durability | 0 | 0 | - | - | ++ |
| | | | | | |
| Total + | 0 | 2 | 3 | 2 | 2 |
| total 0 | 6 | 3 | 2 | 2 | 5 |
| total - | 0 | 1 | 1 | 2 | 0 |
| | | | | | |
| Net | 0 | 1+ | 2+ | 0 | 2+ |
| Continue? | no | revise | revise | no | no |

Figure 11: Concept Scoring Matrix

| | weight % | Reference A | score | Liz-dog | score | Toughy | score | Barack-o-flock-flame | score | god | score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stays on the track | 10 | 3 | 30 | 3 | 30 | 3 | 30 | 3 | 30 | 3 | 30 |
| Weight | 30 | 2 | 60 | 2 | 60 | 5 | 150 | 4 | 120 | 2 | 60 |
| Ability to carry trailer | 15 | 3 | 45 | 4 | 60 | 2 | 30 | 3 | 45 | 3 | 45 |
| Cost | 20 | 2 | 40 | 2 | 40 | 4 | 80 | 4 | 80 | 2 | 40 |
| Aesthetic | 5 | 1 | 5 | 4 | 20 | 5 | 25 | 1 | 5 | 2 | 10 |
| Durability | 20 | 3 | 60 | 2 | 40 | 2 | 40 | 2 | 40 | 4 | 80 |
| | | | | | | | | | | | |
| Total + | 100 | | 240 | | 250 | | 355 | | 320 | | 265 |