Solar Car Project
Team #1 (BAM1)
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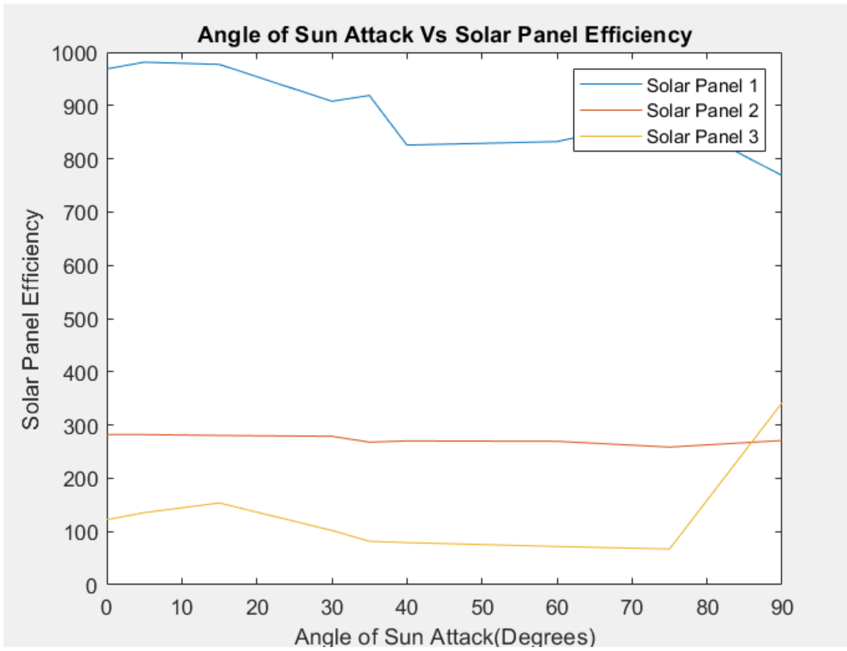
12/8/23

Abstract
This report introduces the Sparkyville transportation system prototype and test results. Design features such as safety features, aesthetic features, and functional features are also discussed with instructions for use. Automation details are also described with wiring and programming setups and steps. Also enclosed in the report are price and budget proposals.

Introduction
This project aimed to address some human and infrastructure issues in a city called “Sparkyville”. The city was facing huge amounts of pressure to become more eco-friendly while also still accommodating the large population and tourists. The growing population liked to travel down Sparkyville's main attraction, “The Sparkyville Strip '' via chauffeured transportation. To fully understand the problem at hand, research had to be done to understand this city’s predicament. The team’s research found that many large cities like “Sparkyville” face major traffic congestion. Places like Los Angeles and Las Vegas are prime examples. The congestion in these cities has numerous negative effects. To name a few, it wastes the time of drivers and passengers, it wastes fuel, which adds to fossil fuel emissions on earth, it interferes with emergency vehicles, and even causes more car crashes. A solution needed to be designed to meet the concerns the city was facing. After interviewing some city representatives, such as the mayor, the taxi fleet commissioner, and numerous frequent travelers, including a family, the solution to this problem could be defined by requirements. To appease the mayor, the solution must be environmentally friendly and safe. Due to “Sparkyville’s” sunny location, the most efficient renewable energy source was determined to be solar power. He also wanted the vehicles to be autonomous. However, the taxi fleet commissioner made a point that the solution must not take away from the jobs of taxi drivers, but, it should implement smart features to help drivers stop running redlights. It would also be beneficial for the solution to carry luggage, be handicapped accessible, and fit large groups of people such as families. These features would be beneficial to tourists and travelers. The final solution would need to suit the mayor, whilst also providing tourists with optimal transportation, and allowing taxi drivers to keep their jobs.

Background
- The sun will be the renewable power source for the vehicle. To calculate the power the car will have to run off of, the input power from the solar panels has to be found. This is found in the equation $\frac{E \times SA}{100}$. E stands for illuminance available in lux and SA stands for the surface area of the solar panel. The 100 comes from connecting the solar panel to a 100 Ohm resistance load. One can then calculate the output power from the solar panels to the motor. The equation for that is Power = Voltage / Resistance for each panel. This tells us how much power will be available for the motor to use to power the car.
- To build an efficient solar-powered car, it was important to perform some experiments to better understand the elements that were dealt with.

- The first experiment dealt with the solar panels. It would prove useful to know how to maximize the power gained from them. An experiment was performed to see which angle the solar panels should be angled at to give the most power from the sun. The results from this experiment found that two of the three types of solar panels tested got the most power from a slight upward angle of around



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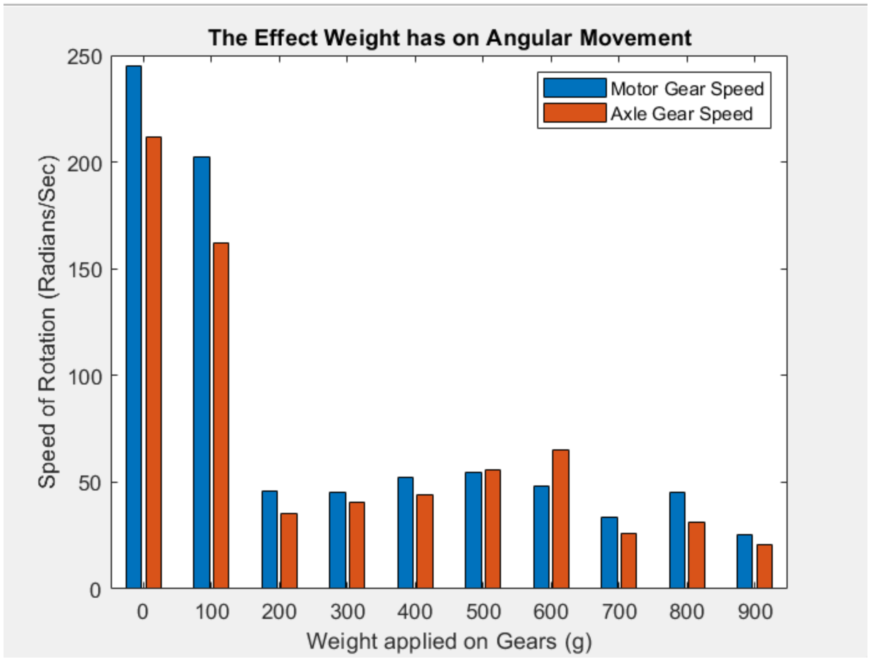
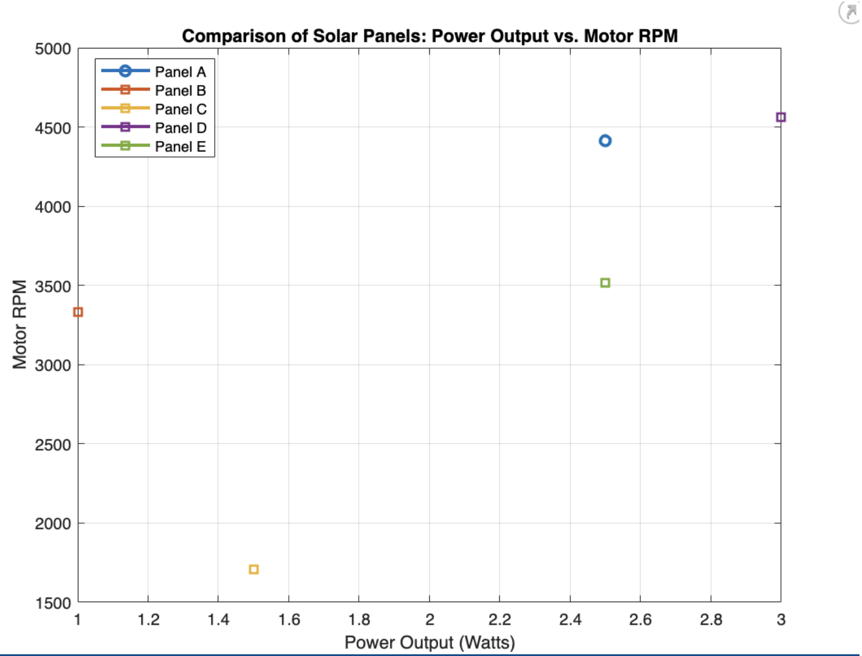
- The second experiment we performed helped us understand how weight affects speed. It was an important concept to observe because we would need to plan out how heavy our car was going to be with our chosen building materials, passengers, luggage, and more. We needed to understand how this weight load would affect the motor and the speed. Based on the results of the experiment, it became clear that the more weight we added, the motor would produce slower and slower rotational speeds. We concluded that the lighter we made our car, the faster it would go.



- The third experiment we performed to help us decide which solar panel was most efficient. In class, we had many different solar panels to choose from. They all had different voltages and wattages. We wanted to find out which of these solar panels would give us the most power and the fastest rotational speed from our motor. From the experiment, we found that the most efficient solar panel was the 12-volt, 3-watt solar panel. It gave us the fastest rotational speed, so that would be the one we would use in our project.



After experimenting with certain aspects, criteria for the prototype were created. Wheelchair accessibility was a big criteria due to the vast need and shortage of wheelchair accessible public transportation. Light Weight was als a big criteria due to the fact that weight significantly slows down moving objects. A light weight was something that would possibly make the vehicle reach closer to its maximum speed. Storage was another large criteria. With the vehicles being used in a very high tourist dense region, luggage will also be very dense. Passenger capacity was another criteria that struck big. Sparkyville is very dense in population, and that makes the need for transport a high need. Being able to hold large quantities of passengers will make transportation along the strip move more brisk and smoothly. A last criteria considered was speed. Tourists don't want their trip to be mostly transportation. They want to get to their destination in a quick manner.

AHP:

Criteria	WC	LW	SC	P	S	**Total**	**Weight**
Wheelchair Accessibility	1	1/7	1/8	1/9	1/6	1.546	0.024
Light Weight	7	1	3	1/2	1/2	12	0.189
Storage	8	1/3	1	1/8	1/6	9.625	0.152
Passenger capacity	9	2	8	1	5	25	0.395
Speed	6	2	6	1/5	1	15.2	0.240
Total						63.371	

A group of criteria were created and rated using an AHP table. With each comparison and rating, it was determined that the capacity of passengers was the most detrimental criteria and wheelchair accessibility being the least important criteria.

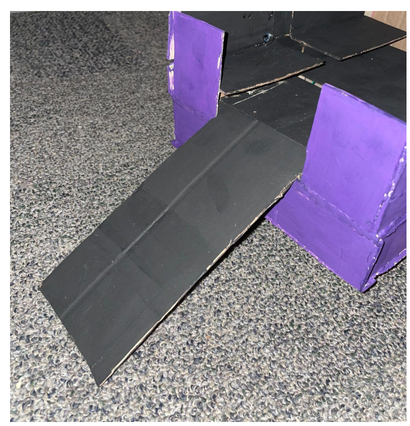
Design Decision Matrix:

Criteria	**Weights (%)**	**Limo**		**Bus**		**Truck**	
		Rating Factor	Weighted R.F.	Rating Factor	Weighted R.F.	Rating Factor	Weighted R.F.
Wheelchair Accessible	2.4%	2	0.048	5	0.12	5	0.12
Light Weight	18.9%	5	0.945	2	0.378	3	0.567
Storage Compartment	15.2%	2	0.304	3	0.456	5	0.76
Holds a Large number of passengers	39.5%	4	1.58	5	1.975	5	1.975
Speedy	24%	4	0.96	2	0.48	4	0.96

Total	100%	3.837	3.409	4.382

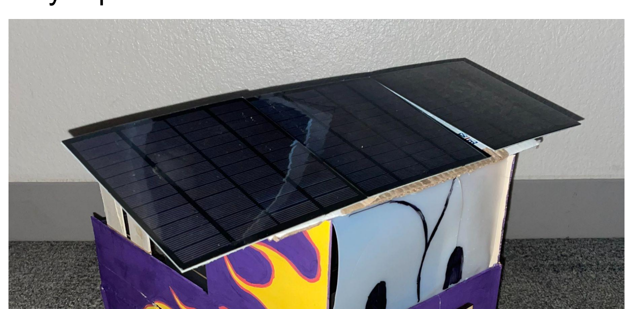
After each criteria was determined in order of importance, each was scored for each different design prototype. A score of 5 represents a perfect score and the criteria is fully accomplished in the prototype. A score of 1 means that the criteria is not included or has little representation in that prototype. With all of the scoring combined, the truck had the highest criteria score. That meant the truck prototype would become the main prototype within the design process.

- Our design came from a mix of different inspirations. We drew inspiration from party buses because we wanted our car to be a fun party experience for intoxicated people. It would be safe to keep drunk people off the streets this way, and it would be fun for them because of all the party aspects we wanted to add. For our seating arrangement, we drew inspiration from those pumpkin patch tractor rides. We wanted it to be an outdoor experience, so that is why we decided to place the passenger seats in the back of the truck in the bed. Our paint job was inspired by the character “Ramone” from the Disney movie “Cars”. We wanted it to be fun and exciting to attract people. As for the mechanics of our project, we did some research on groups who had previously done similar projects. We drew inspiration from them on how to build ours. For example, we followed a “Science Buddies” experiment to learn how to set up our gear train, and which size gears to use where (*Build a Solar-Powered Car: Science Project,* n.d). We drew inspiration for the construction of our axles from a Youtube video posted by the creator “How To Raju”, which is why we ended up using straws to hold our dowels in place (How To Raju, 2022).

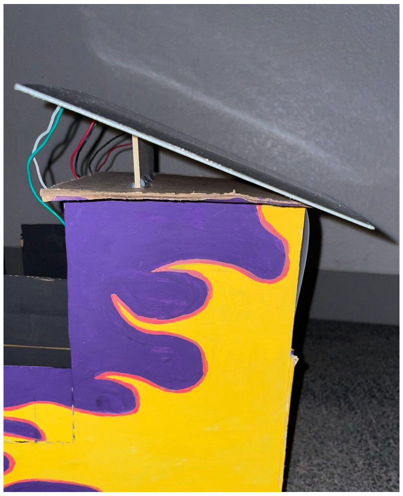


Design Description:

We determined that the basic structure of our design was going to resemble a truck. We made an orthographic drawing as a blueprint, that we would follow as we built our car (see Appendix 1 for Orthographic Engineering Drawing). We followed the drawing to build parts for the basic structure and body. We wanted to do this to have a unique place to carry all the passengers, the bed. For the entire body of the truck, we used a mix of ply and balsa wood because we wanted the car to be durable. For the insides, the ramp, the seats, and the solar panel rack, we used cardboard because it still holds its shape but is lighter in weight. For a windshield, we used some plastic from a recycled gallon jug. The body was then painted with acrylic paint and markers. We stuck all of the pieces of the body of the car together using

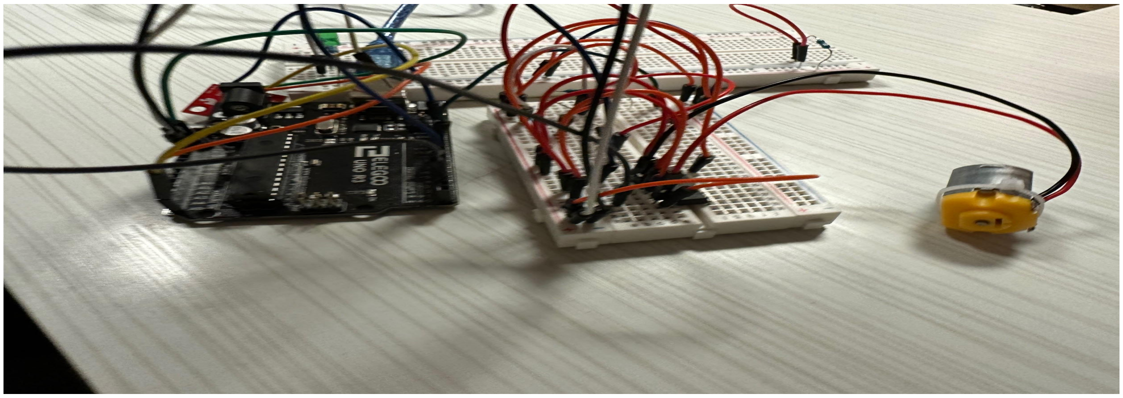


ample amounts of hot glue. The tape was also used in some places for extra security.



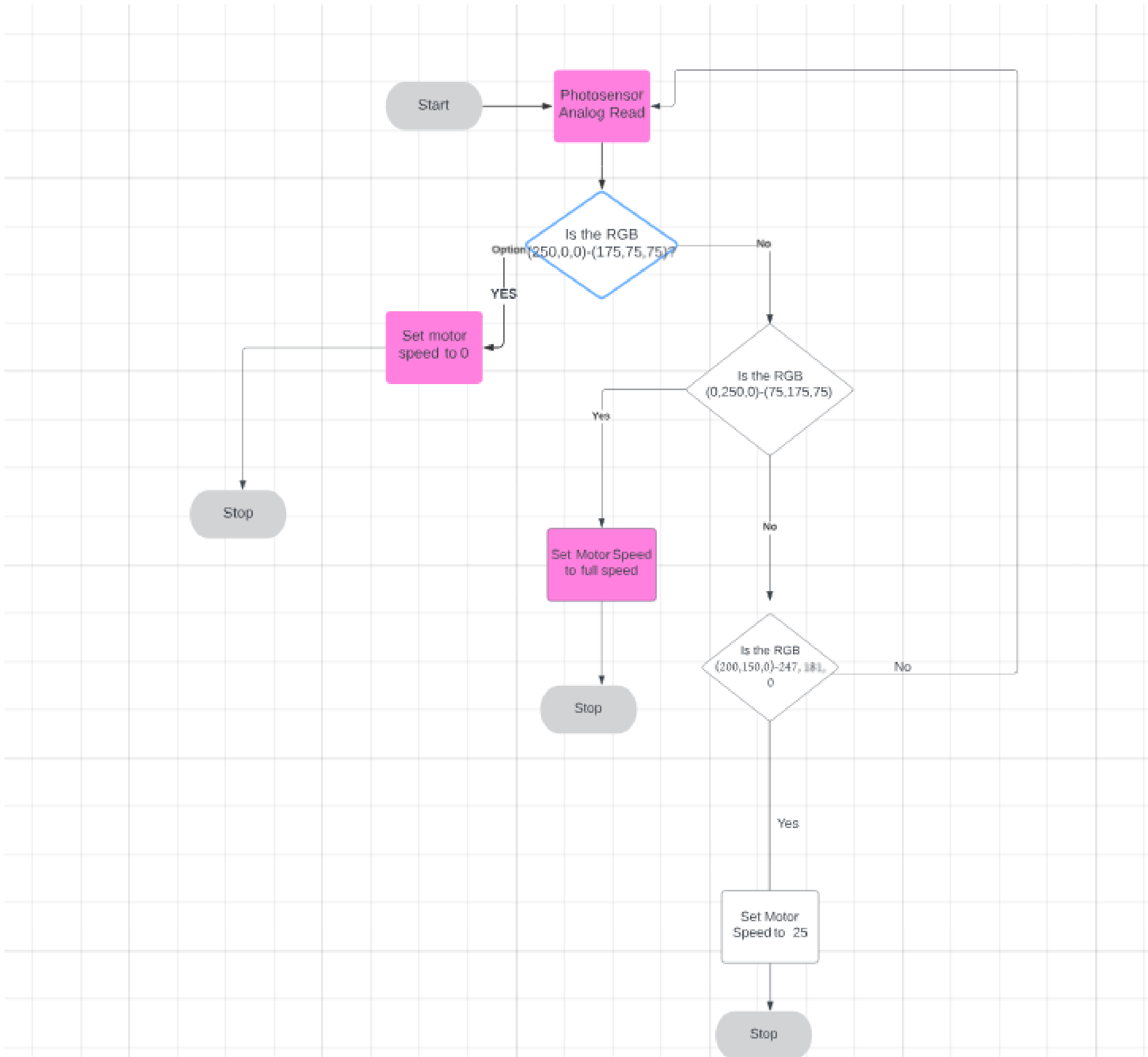
For the actual functionality and propulsion of this project, we of course needed a motor, gears, wheels, and an axle system. We decided to go for a larger motor, the n99 motor, to be able to handle more power. We ended up using three twelve-volt, three-watt solar panels to power the motor. These panels were angled upwards at about fifteen degrees to intake the greatest amount of sunlight possible, as found from some experimenting. This motor also had a ten-tooth gear attached directly to it. Then, the ten-tooth gear aligned with a fifty-tooth gear, which was glued to our back axle. Our axles were made up of metal dowels that ran inside of some straws that were hot glued to the bottom of the car. This allowed the gears to spin the axle inside of the straws, and the tires without any resistance. The tires were made out of pulley wheels with O-rings on the outside. These tires were lightweight and spun effortlessly. This way, when the solar panels charged the motor, the little gear would spin the big gear, which would spin the axle, causing the wheels to turn and the car to move forward.

For the automation part of the project a L293D motor driver was used as a motor controller. This driver gave the arduino and motor and RGB sensor full control of the motor speed and the power for the RGB sensor to cut all mobility in the motor. The RGB sensor was used as a light sensor to be able to detect a redlight and a greenlight to allow. This would print the values into the serial monitor to allow for the arduino to measure the values to be able to flip the switch on the motor power to stop the motor from running. For all of this to be working properly a code needed to be created. The code created is 89 lines long and works in a pressure switch fashion. The first step of the code which was created was to allow libraries to be active in the code itself. Next step in the code was to define motor connects which was quickly followed up by motor stops and motor start texts. Next was the setup for motor control which was followed up by initializing the RGB sensor. Following this was the printing of the motor colors and the values needed to start and stop the motor depending on which value was dominant. Next was the color motor control which stopped and started the code and which finally started and stopped the motor due to the RGB dominant color. All of this was done by connecting an arduino, breadboard, and motor together and having a code be executed in the arduino to allow for functionality to be controlled. Next was the wiring in the sector of automation. We had power running into the breadboard powered by the solar panels on top of the vehicle. We also had an arduino powered by a battery. Our RGB sensor was wired into the arduino into the pins; GND, A4, A5, 3.3v power in the arduino. The L293D driver had wires running into positive and negative on the breadboard and also had motor wires running into the board to give the motor power and allow for the driver to have full control of the motor power through the code. The rest of our wiring was used to control power and to help regulate power running through the board using resistors or transistors. Overall our automation was well created and allowed for our motor to run perfectly to what it was designed to do.



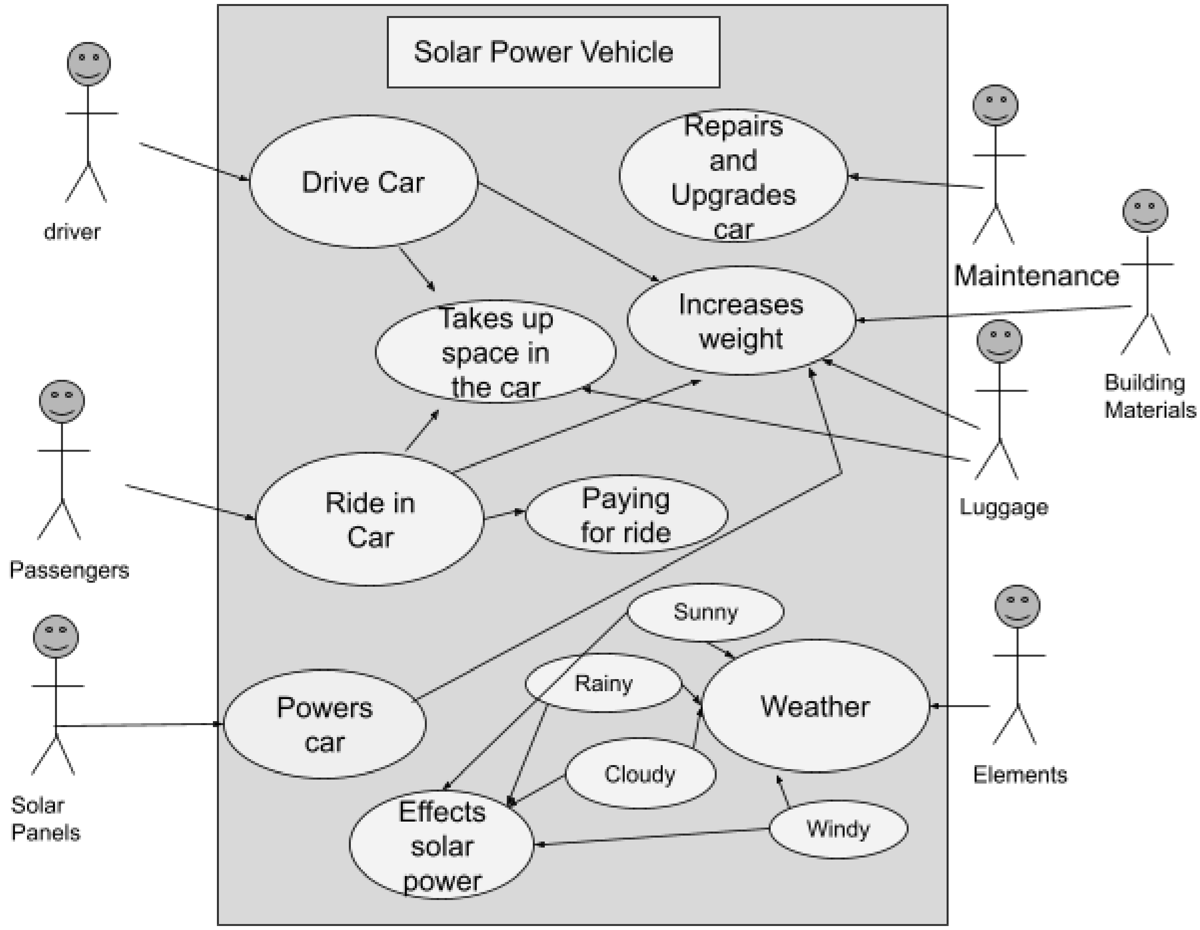
While making this project, many complications caused us to make some tradeoffs from our original design idea. For example, our axles were originally made out of wooden dowels. However, these bent under the weight of the car and wouldn't align with the motor gear. So, we changed the wooden dowels to metal ones, they were much more sturdy. We also had to change a lot of the frame from the wood we had originally planned to cardboard. This cut down on the weight of the whole project which made it easier for the motor to move the car faster.

During the process of constructing this project, we created an activity diagram to help us brainstorm what we wanted the car to do. We used an activity diagram specifically for our code. It helped us map out what decisions the car would make in different situations. For example, we had to program the car to sense red lights with the RGB sensor. So, in the activity diagram, the car had to make a decision. If a high value of red was sensed, the car was to stop, or in other words, have a motor speed of zero. If the threshold of red light was not reached, the car was not to stop, or continue at full speed.



In case there wasn't a large enough presence of red light to meet the threshold to stop, but there was a significant amount, we wanted to program the car to slow down. This was a precaution we wanted to take. It would be like a car slowing down when the driver sees a yellow light.

Another significant part of the brainstorming process of our project was creating a Use-Case Diagram. This diagram helped us understand who and what would be interacting with our car and how that would affect it. This would help us plan what we would need to build to satisfy all of the interactions. The main users that would affect our project included the driver, the passengers, the weather, the solar panels, maintenance, any luggage, and the building materials we chose to use. All of these users would change the design of the car in different ways. For example, the driver and passengers would need a place to sit, so we had to ensure they all had seats. The building materials would increase the weight, so we had to make sure our motor would get enough power to handle all the weight. The weather would affect the amount of power the solar panels could generate. If it were rainy or cloudy, those interactions would not allow the panels to get enough sun, which would then affect our car's speed.



In the diagram, the stick figures represent the users, the bubbles represent the cases or outcomes. The arrows represent the flow from input to output. Some arrows pointed towards the output, which meant they were guaranteed to happen, there were no options. If the arrow pointed towards the input, that meant the outputs were all possibilities or choices that could happen, but weren't guaranteed.

Predicted Speed:

According to experiment 2 within memo 3, the RPM for a 10-tooth gear to a 50-teeth gear with 9kg of weight (The highest quantity of weight experimented with) spun at 240 RPM (Appendix 2). The diameter of the wheels used was 50mm, so a circumference of 50π was calculated.
To get the total distance traveled within 1 minute, we multiplied our circumference(Distance traveled for one rotation) by 240 (Rotations per minute) to get 12000π mm traveled in a minute. The value needed is in seconds, so the value is divided by 60 to get 200π mm per second. The value needed is required in ft/s, not mm/s. A conversion was made with 1 ft/304.8 mm to get 2.06 ft/s

Design Implementation:

Purchase Date	Quantity	Item Description	Per Item Cost	Total Cost	Remaining Budget
10/27	1	Breadboard	$2.00	$2.00	$78
10/27	1	Arduino Uno	$20.00	$20.00	$58
10/27	1	Light sensor RGB	$5.00	$5.00	$53
10/27	2	Balsa wood	$0.50	$3.00	$50
10/27	2	Wooden dowels	$0.10	$0.20	$49.80
10/27	4	Jiffy clips	$0.20	$0.80	$49
10/27	1	N99 motor	$5.50	$5.50	$43.50
10/30	2	Solar panels	$8.99	$17.98	$25.52
10/30	4	Pulleys 50 mm	$0.50	$2.00	$23.52
10/30	4	D-rings 50 mm	$0.25	$1.00	$22.52
10/30	2	Recycled cardboard	$0.20	$0.90	$22.12
10/30	1	40 tooth gear	$0.60	$0.60	$21.52
10/30	1	30 tooth gear	$0.50	$0.50	$21.02
10/30	10	⅛ grommet	$0.10	$1.00	$20.02
10/30	2	Recycled balsa	$0.70	$1.40	$19.62
11/6	2	⅛ ply	$0.70	$1.40	$18.22
11/6	1	2 recycled balsa scrap	$0.10	$0.10	$18.10
11/6	4	Straws	$0.05	$.05	$18.05

<u>Budget Summary:</u>

Of the many pieces of the solar-powered car, several pieces are crucial to its design. The motor and gears used are crucial for peak functionality. The motor spun at a very high RPM which fed into the gears. The gears used (50 tooth: 10 tooth) provided less torque on the motor allowing for smooth acceleration and less work done by the motor. This decreased work on the motor allows for a longer lifespan on the motors as well. Another crucial component of the solar power car is the solar panels used. The solar panels used were each 12 volt and 3 amp panels. Three of these panels were used allowing the vehicle to have 36 volts of power and 3 amps of power. In addition, these panels had a large surface area which made light absorbance more efficient for the vehicle.

Factory Tests:

There were several procedures that the prototype vehicle had to go through to be able to be deemed successful for Sparkyville

The first test was testing the handicap accessibility within the vehicle. A handicap ramp was installed on the vehicle, and it passed the test regarding it functioning properly. The test procedure can be seen in Appendix 3

The next test regards the vehicle running entirely off of the renewable power source of solar energy. The vehicle had 3 12-volt, 3-amp solar panels providing the energy needed to run. The vehicle passed the tests and was found to run successfully entirely off of solar energy. The test procedure can be seen in Appendix 4.

Another test for the vehicle regards the ability of the storage compartment to work successfully and store the needed luggage without issues. The vehicle was installed with a sealable storage compartment that runs along the length of the vehicle. The vehicle passed the test and successfully held golf clubs, and two suitcases in the sealable storage compartment. The test procedure can be seen in Appendix 5.

The 4th test the vehicle was to undergo was testing for the vehicle to reach the estimated speed of 2.06 ft/s. Through a multitude of tests and calculations seen above, the vehicle was predicted to have a running speed of 2.06 ft/s. The vehicle failed this test, with it reaching 0.9828 ft/s or 47.7% of the estimated speed The test procedure can be seen in Appendix 6.

The last test the vehicle went through tested the ability to hold at least 5 passengers and hold them safely. The vehicle was suited with individual seats each with its seat belts. There is even a custom seat belt for wheelchair-bound passengers. The vehicle passed the test successfully with a wide variety of seating options and safety features. The test procedure can be seen in Appendix 7.

Functionality:

During the official prototype test, the vehicle's automation worked as planned. The vehicle was able to detect a red light with the color sensor and force the motor to stop. The vehicle was also equipped with the ability to sense a green light and begin running the motor.

The hypothesized running speed of the vehicle was 2.06 ft/s. During the test, the vehicle only reached 47.7% of that value running at 0.9828 ft/s. This was due to an increase in weight resulting in an unexpected load on the motor. With some slight modifications to the motor's positioning, the speed of the vehicle should increase to a value closer to the predicted speed.

The vehicle was able to hold and restrain the passengers safely during the vehicle's test. This was achieved by the safety seat belts that were a part of all 5 seats as well as the wheelchair spot.

Physical calculations:

For the vehicle, the Nichibo 10500 RPM motor was used granting a torque equation of .00000204 (240)+ 0.0255 to get a torque of 0.0259896 Nm

The power of the vehicle's drive system was calculated using the equation, P = (0.0259896 Nm)(25.1327) = 0.65318881992 W

The efficiency of our system was calculated using the equation, (0.65318881992/5.900973)*100= 11.07%

Final cost-benefit analysis:

This is a worthwhile endeavor that will bring in money for the company. The total cost of the endeavor is $676,800 annually with an annual benefit profit of 2.7M. This comes together to give the project a lifelong profit of 53.988 million.With an annual return of 39.9%, we have an excellent return on investment that helps us meet our needs and will continue to fund our future endeavors. By providing access to those without a means of transportation and reducing emissions and pollution through ride-sharing, which lowers the number of cars required on the road, this initiative has improved both transportation and the environment. However, our travel time for 20 ft. is slow with an average speed of 0.9828 ft/sec and a time of 20.35. This can affect our performance as a company. With other companies competing, we would need to enhance our travel time so that is faster and more efficient. All things considered, this project has potential that deserves to continue.

Conclusion

- Throughout this project, we have gone through several processes. We began by doing research regarding the issue. We found what the requirements were and did research on the customers. We then conducted experiments to help in the upcoming step of product design. For the first experiment, we found how much the intensity of sunlight affects the effectiveness of solar panels. We found that the more intense the light is, the better the efficiency of the graph is. It does flatten at some differing point for each panel. We then found how the weight on the gears and drive system affects the rotational rate of the gears. We found the more weight that is on the gears, the slower the rotational speed. It also requires a larger amount of torque to get the gear spinning. We then experimented to see how the angle of sunlight affects the light absorbance for solar panels. We found that an angle between 15-30 degrees is optimal for light absorbance. The next part of our experiment was to design and sketch a prototype. We produced an AHP table to score our criteria as well as a design matrix to rank our criteria. Once that was completed, an orthographic sketch was created with all necessary details included. Details such as wires management, seats, and criteria. The next step was to begin constructing our prototype. We started with installing the drive system with the gears and the motor. We then began to construct the body in pieces. A trunk, a cab, and the seats. Once every piece was complete, each piece was joined together to form a completed truck. Detailing followed with a custom nameplate added as well as a yellow and purple paint job.

If there were less of a time constraint, there are several things that we would do differently. For one, we would begin by installing multiple motors in the front and back tires. This would help the car move with more power. We would also modify the overall shape of the car to have better aerodynamics. We would also swap out the balsa wood for styrofoam to have a lighter and slightly more sturdy truck. Another modification we would do is to switch up the tire to be more sturdy and have more traction. Some tire alternatives are plastic jar lids or Lego tires. We would also want to expand more on the weight effect on speed. Moreover, many lessons were learned throughout this project. One was time management and understanding the value of planning. The importance of detailed plans and blueprints can make the work of the project go smoothly. Communicating was key in this project since everyone needed to be on the same page and know what the priorities were. Facing unexpected obstacles was something we had to overcome and tackle. Being prepared to face these challenges can help. Lastly, we learned about programming and coding sensors which was new to everyone. In summation, this project gave us valuable knowledge in all aspects of planning, building, and teamwork which helped build better chemistry between us.

References:

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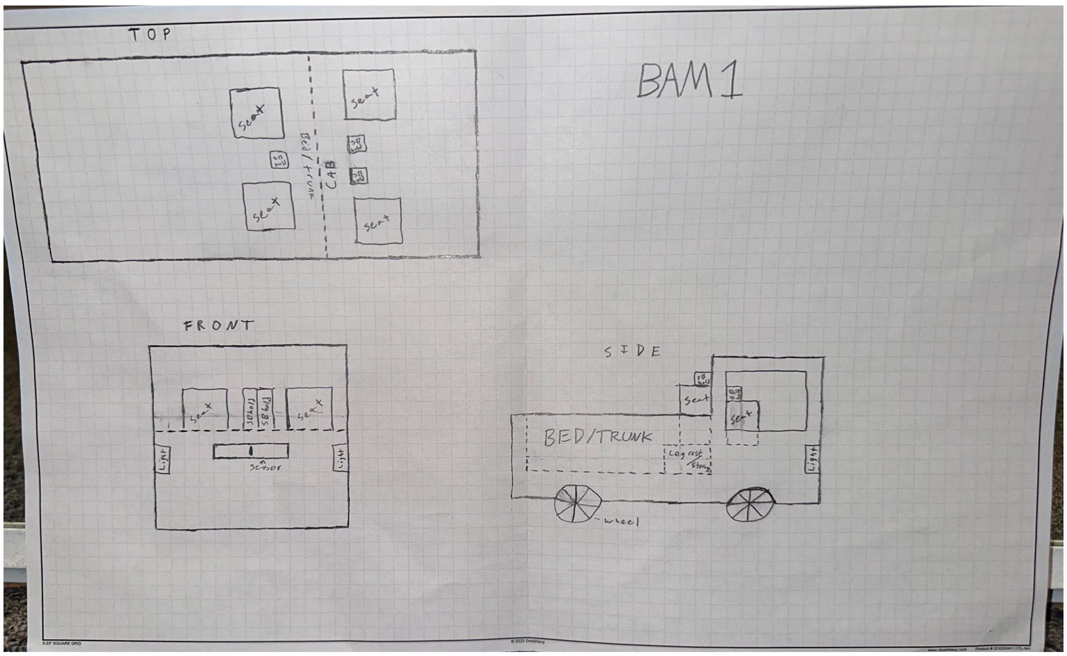
Appendices

Appendix 1: Orthographic Engineering Drawing



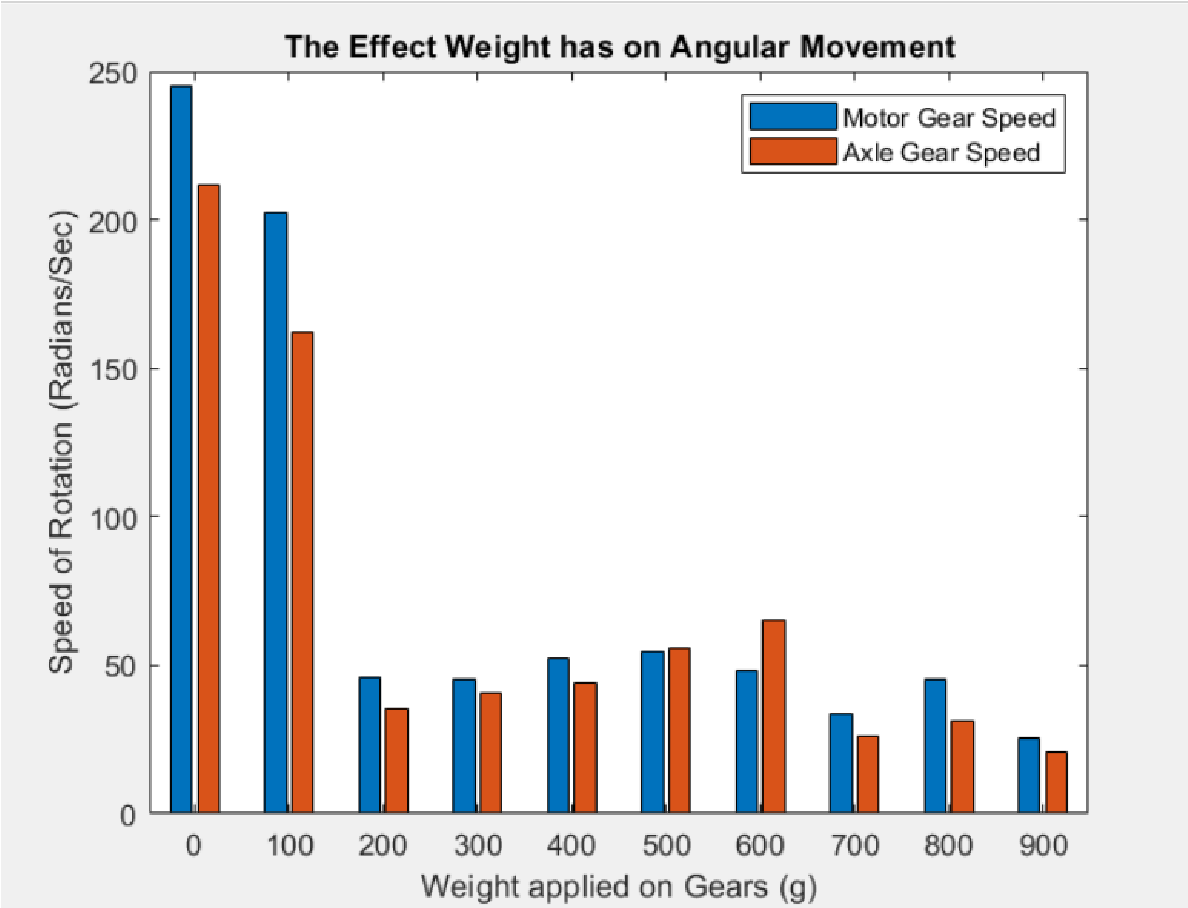
Appendix 2: Detailed Calculations

Torque of motor - 0.00000204 (240)+ 0.0255 = 0.0259896 Nm

Power of motor - P = (0.0259896 Nm)(25.1327) = 0.65318881992 W

System Efficiency - (0.65318881992/5.900973)*100= 11.07%

Weight Vs. Speed Experiment Data



Appendix 3: Factory Acceptance Test Procedures

Handicap Accessibility Test

Test 1 Title: Truck is handicap accessible

Scope: This test verifies the wheelchair ramp functions and the truck has wheelchair constraints.The following requirements are included in this procedure:

1. Wheelchair accessibility

Name of Tester: ***Date of Test***:

Prerequisites:

- Truck is present with rear facing tester
- Wheelchair is in hand and ready

Test Procedure:

Step	Instructions	Expected Outcome	Requirement	Pass/Fail
1	Locate the black wheelchair ramp in the bed	The ramp is sitting in the bed in the aisle-way		
2	Pull the ramp out of the rear through the designated slot	The ramp is sticking out of the rear towards the tester		
3	Pull the ramp down to the floor	The ramp is touching the ground		
4	Move the wheelchair up the ramp into the bed	The wheelchair rolls onto the ramp and fits into bed		
5	Strap the wheelchair into the wheelchair section	VERIFY the wheelchair is facing the left side of the bed. The tan wooden poles are holding the wheelchair and passenger in place with the rubberband seatbelt	REQ 1: Wheelchair enters the bed of the trunk using the ramp	

Solar Energy Test

Test 2 Title: Vehicle Functions on Solar Energy

Scope: This test verifies that the vehicle functions solely on solar energy
The following requirements are included in this procedure:

2. The car shall be moving solely on solar energy

Name of Tester: ***Date of Test***:

Prerequisites:

- Complete assembly of the car
- Wired up Solar Panels
- The car must be outside

Test Procedure:

Step	Instructions	Expected Outcome	Requirement	Pass/Fail
1	Face the front of the car into the light source all while holding the car	A shadow should form behind the truck, not in front of it while the car is in the testers arms		
2	Ensure the front of the car is not covered by anything	The red color sensor should be visible through the cut out slot at the very front of the vehicle (below windshield)		
3	Drop the vehicle on the ground from a maximum height of 1 inch	The vehicle should have a bit of bounce to it after hitting the ground		
4	Wait about 15 seconds maximum for the vehicle to start moving	VERIFY The car moves in the forward direction without assistance	REQ 2: The car is moving solely off solar energy	

Storage Compartment Test

Test 3 Title: Storage Compartment functioning

Scope: This test verifies that the storage compartment holds any luggage or items the passengers may have.

The following requirements are included in this procedure:

3. The storage compartment functions and holds the golf clubs, and suitcases.

Name of Tester: ***Date of Test***:

Prerequisites:

- The suitcases and golf clubs are in hand and ready
- The rear of the vehicle is facing the tester

Test Procedure:

Step	Instructions	Expected Outcome	Requirement	Pass/Fail
1	locate the storage compartment at the front of the bed	The black box made of tape and cardboard resting on the back of the cab seats is found		
2	Open the storage compartment	The black cardboard cover should bend backward revealing a compartment		
3	Place the clubs and luggage in the compartment	The clubs and the luggage fits snuggly in the compartment		
4	Close the storage compartment	VERIFY luggage fits in the compartment with the lid closed	REQ:3 The storage compartment holds luggage and clubs in a resealable compartment	

Predicted Speed Test

Test 4 Title: Speed of the Car

Scope: This test verifies the speed of the car to its predicted linear speed
The following requirements are included in this procedure:

4. The measured and tested speed shall be close to the predicted linear speed for the car is 2.06 ft/sec

Name of Tester: ***Date of Test***:

Prerequisites:

- Complete assembly of the car
- Marked test surface
- Measuring tape or marker
- Timing device in seconds

Test Procedure:

Step	Instructions	Expected Outcome	Requirement	Pass/Fail
1	Line the vehicle up on the marked track	The very front of the vehicle shall be flush with the marked line indicating the start		
2	Drop the car from 1 inch max off the ground	The car should have a bounce to it, and the motor should start immediately		
4	Time the car when it starts moving	Once the vehicle has a noticeable forward movement of any kind, start the timer measuring in seconds		
5	Stop the timer when the car reaches the end of the track	Stop the timer as soon as the rear of the vehicle crosses the marked line indicating the finish		
6	Divide the total time in seconds by 20 to get the speed in feet per second	VERIFY the total amount of time in seconds is recorded and divided by 20 to get a value recording the vehicles speed in feet per second	REQ #4 The speed of the car in ft/second is measured and matches the estimate of 2.06 ft/s closely	

Passenger Seating Safety Test

Test 5 Title: Passenger Seating

Scope: This test verifies that the riders fit and are secured in the vehicle
The following requirements are included in this procedure:

5. The vehicle safely holds 5 passengers

Name of Tester: *Date of Test*:

Prerequisites:

- The passengers are available
- The rear of the vehicle is facing the tester
- The seats are in the car

Test Procedure:

Step	Instructions	Expected Outcome	Requirement	Pass/Fail
1	Place 2 passengers in the front seat, from the open back panel	Past the storage compartment, the 2 passengers can be placed in the compartment		
2	place remaining passengers in seats in the bed seats	passengers should be sat on the black cardboard seats sitting on the sides of the bed		
3	make sure passengers are sitting upright	the passengers should be upright with legs pointing downwards towards the floor and their head at or above the top of the seat		
4	strap passengers onto seats using the rubber band seatbelt	VERIFY the passengers are secured in the vehicle with the rubber band around their waist	REQ:5 The car safely holds a minimum of 5 riders	

Appendix 4: Arduino Code

```
#include <Wire.h>
#include <SparkFunISL29125.h>

// Motor control using L293D with Arduino Uno

// Motor A connections
int motorAPin1 = 2;  // Input 1 of L293D
int motorAPin2 = 3;  // Input 2 of L293D
int enableAPin = 9;  // Enable A of L293D

bool motorRunning = false;
bool motorStopRequested = false;
```

```
unsigned long lastStopTime = 0;
const unsigned long restartDelay = 5000;  // Adjust the delay time as needed (in
milliseconds)

SFE_ISL29125 RGBsensor; // Change ISL29125 to SFE_ISL29125

void setup() {
 // Initialize Serial communication
 Serial.begin(9600);

 // Define the motor control pins as outputs
 pinMode(motorAPin1, OUTPUT);
 pinMode(motorAPin2, OUTPUT);
 pinMode(enableAPin, OUTPUT);

 // Initialize the motor to stop (no movement)
 digitalWrite(motorAPin1, LOW);
 digitalWrite(motorAPin2, LOW);
 analogWrite(enableAPin, 0);  // Set speed to 0 initially

 // Initialize the RGB sensor
 if (!RGBsensor.init()) {
   Serial.println("Error initializing the ISL29125 sensor. Please check your
connections.");
   while (1); // Stay in a loop if the sensor initialization fails
 }
}

void loop() {
 // Read RGB values from the sensor
 int redValue = RGBsensor.readRed();
 int greenValue = RGBsensor.readGreen();
 int blueValue = RGBsensor.readBlue();

 // Print RGB values to Serial Monitor
 Serial.print("Red: ");
 Serial.print(redValue);
 Serial.print(" | Green: ");
 Serial.print(greenValue);
 Serial.print(" | Blue: ");
 Serial.println(blueValue);
```

```
 // Check if the red light is detected (adjust the threshold values)
 if (redValue > 900 || (greenValue < 5 && blueValue < 5)) {
   // Red light detected
   if (!motorStopRequested) {
     // Stop the motor only once when red is detected
     motorStop();
     motorStopRequested = true;
     lastStopTime = millis();  // Record the time when the motor was stopped
   }
 } else {
   // Red light not detected
   if (motorStopRequested && !motorRunning && millis() - lastStopTime >= restartDelay)
{
     // Start the motor only if it was previously stopped, is not running,
     // and enough time has passed since the last stop
     motorForward();
     motorStopRequested = false;  // Reset the stop request flag
   }
 }

 delay(1000);  // Wait for 1 second before the next iteration
}

// Function to make the motor move forward
void motorForward() {
 digitalWrite(motorAPin1, HIGH);
 digitalWrite(motorAPin2, LOW);
 analogWrite(enableAPin, 255);  // Set speed to maximum (255)
 motorRunning = true;
}

// Function to stop the motor
void motorStop() {
 digitalWrite(motorAPin1, LOW);
 digitalWrite(motorAPin2, LOW);
 analogWrite(enableAPin, 0);  // Set speed to 0
 motorRunning = false;
}
```

Appendix 5: Cost Ananlysis

TYPE	VALUES	EQUATION	TOTAL
Recurring Loan Payment	Initial Cost: 676,800 Interest: 6% per year Lifespan: 20 years= 240 months	A= $\frac{P(1+r)^n}{(1+r)^n-1}$ 676800($\frac{0.06(1+0.06)^{240}}{(1+0.06)^{240}-1}$)	$40,608.03
Total Annual Cost	Capital: 676800($\frac{0.06(1+0.06)^{20}}{(1+0.06)^{20}-1}$)= 59006.50 OMR: 200,000	Capital + OMR 200,000+ 59,006.50=	$256,009.51
Total Annual NET Benefit	Taxi fare costs: $ 1.442 Total Costs:256009.51	Total profits-total costs (1.442*60*12 hours per day*5days*52 weeks*10cars) - 256009.51=	$2,699,424
Annual ROI	Yearly profit: $2,699,424 Present Cost: 676,800	Yearly profit/ present cost $\frac{2,699,424}{676,800}$=	.399 or 39.9%
Lifetime Cost	Annual Loan payment: 40,608.03 Lifespan: 20years Initial cost: 676,800	(Annual loan payment* years)+ initial cost (40,608.03*20)+ 676,800=	$812,160.60
Lifetime NET Benefit	Total annual NET benefit:$ $2,699,424 Lifespan: 20 years	Total annual NET benefit * years $\$2,699,424 \times 20$=	$53,988,480
Lifetime ROI	Lifetime profit: $53,988,480 Lifetime cost: $812,160.60	Lifetime profit/ lifetime cost $\frac{\$53,988,480}{812,160.60}$=	66.475 or 6,647.5%