MECH 2412 – Mini Design Project 1
Final Report

LAB 03 Group 4
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Statement of Participation

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Executive Summary

This report was written to present our design, prototyping results, and learning results as a part of the MECH 2412, Mini Design Project 1 course offered at York University as a part of the main curriculum. This report was to fulfill the requirements of the final part of the course-long project. The course-long project consisted of three phases, conceptual, embodiment, and final design respectively. The project required us to design something that resembled a go-kart in concept, which had to be remote-controlled and battery-powered but also had to be a solution to a problem that we had created. This problem of ours was to make a vehicle that could help or automate search and rescue operations in the hiking trails outside of the GTA.

This report aims to convince possible investors and our professors that our solution is both viable and realistic so we can receive full marks. This semester-long project has seen substantial growth since the start from a jumble of fantasy car ideas to a professional work vehicle. The progression of this project can be clearly outlined by the formatting of this report with more emphasis on our finishing touches of the design.

The first two sections of our report recall the first two reports we did on the project. Section one underlines our conceptual design, going over the problem background, our initial designs, and reflections when looking back. Our biggest oversight in this section is that we could have had a more complex design if we properly organized our morphological chart with options that fit in with the project outline. Section two describes our embodiment designs, which allowed us to finalize our calculations and choice of materials. Most of the choices made in embodiment stayed unchanged till now due to the confidence we had in our work and the results that it produced. The final section details our final design and prototyping results. Our design remained mostly unchanged from start to finish with the biggest change being in the frame that houses the victim with it becoming more of a resting area rather than a cage. Our biggest challenge in prototyping was the gearbox due to it not moving as smoothly as possible, otherwise the car works as intended.

At this moment in time, even if this report describes our final design, this project is but a budding idea with a lot of kinks to be worked out and optimized. The potential of this project was ultimately limited due to the ongoing strike that is happening at York University, which diminished the amount of guidance that was available to us. As engineers, we persevered till we got something we were happy with in the form of our search and rescue vehicle.

Section 1: Conceptual Design

1.1) Problem Background, Context, and Objectives

Our initial problem scenario was that the provincial government of Ontario was looking for companies to develop a search and rescue vehicle. This was due to all the people who had gone missing after the pandemic when a great deal of people decided they wanted to go hiking. These people went missing due to a multitude of reasons which include but are not limited to; Negligence, Horseplay, and Poor Planning. The provincial government did send search and rescue teams to each case, but they only have so much manpower. With so many teams out looking, it cost the government a lot of money in terms of working hours, so before it turned into a liability and a debt, the provincial government used the rest of the budget to implore engineering firms to develop a solution. To lessen the burden further, the government also explored some of the engineering students at York University to work alongside the engineering firms.

From our initial conceptual report, we deduced a couple of objectives for the problem, having two primary objectives and three secondary objectives. The primary objectives are comprised of “Durability and Reliability” and “Carrying Capacity”. Durability and reliability refer to its ease of maintenance and choice of building materials to ensure it always runs efficiently and sturdily. Carrying capacity is about how much it holds, how efficiently it uses the space, and how it distributes the load. For our final project, we feel as if we haven't left these primary objectives out of our sight because it was the foundation of a search and rescue vehicle. Anything otherwise would just make it a regular car. The secondary objectives were “Energy Efficiency”, “Sustainability” and “Interface and Control”. These objectives were more loosely followed because during the conceptual design, a lot less was thought about what we were going to use to make the car, and more thought was put into how. The sustainability objective especially since ease of disassembly was under it. We now notice that it should have been its own objective with how much we changed the design from the initial draw-up.

1.2) Needs, Stakeholders, and Requirements

Stakeholder	Connection to the Problem	Value	Needs of Stakeholder
Hikers	They are directly affected by the problem, they are at risk of getting lost or injured.	High	Safe and well-maintained hiking trails, and effective emergency response systems.
Provincial Government of Ontario	Providing budget and Managing the search and rescue operations. Accounting for people	High	Cost-effective and efficient solutions, ensure public safety
Search and Rescue Teams	The people who have to search on foot and by helicopter, both are dangerous and have a lot of potential risk	High	A low-risk, high-yield solution to aid in their jobs, but not replace them.
Engineering Firm	They are hired by the government to develop a technology solution to the problem. They have a financial and professional stake in this. Also responsible for the YorkU students.	Medium	Clear guidelines and requirements, and adequate resources to develop their solution
Students at York University	They are tasked by the engineering firm to develop the emergency aid robot. They have an academic and professional stake in the project.	Medium	Clear project guidelines, adequate resources, and support from the university
General Public	They have a general interest in public safety and the resolution of the problem. They have the potential to become direct stakeholders if they go hiking.	Low	Assurance about public safety, transparency about measures taken to address the solution.
Emergency Medical Services	They are the first responders who provide medical treatment to the injured/lost hikers. The proposed technology could assist them by providing them with initial medical aid, reducing response time.	Medium	Effective communication with the search and rescue teams, tools and technologies that can aid in their operations. Ample time to make retrievals

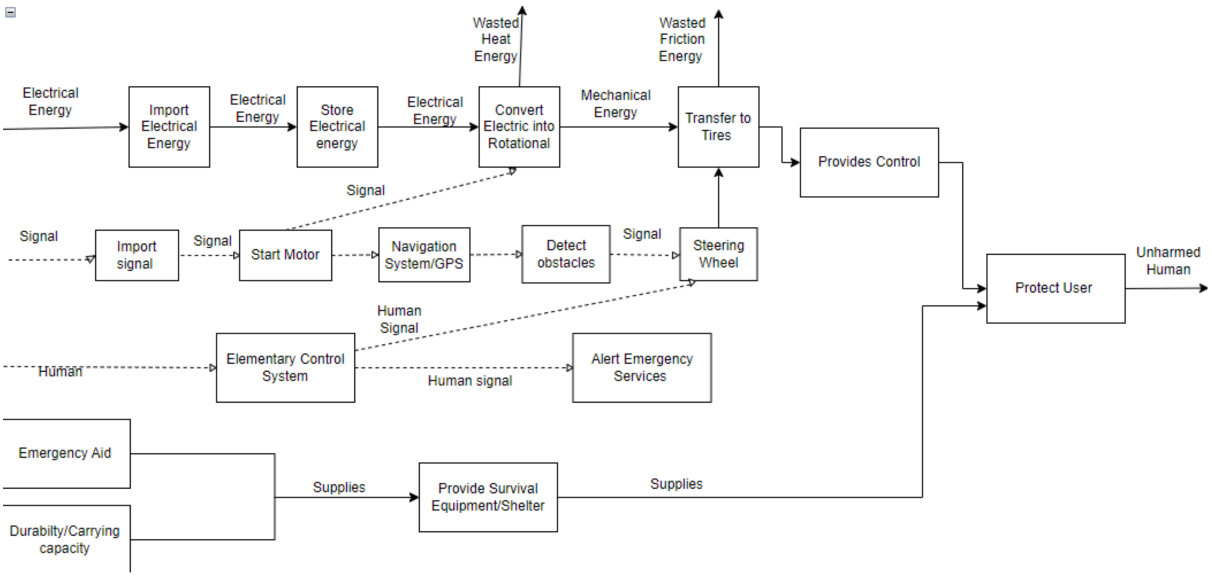
(Table 1: Stakeholder Register)

Requirement Type	Requirement	Validation Approaches and Timing
Functional	The safety vehicle will contain necessary items to help someone survive in the wild. It will be equipped with a first aid kit, flare gun kit (1 flare gun and 4 flares) , 1 walkie talkie connected to the nearest Search and Rescue network, 12 energy bars, 4 two litre water bottles, map of the park/region, 1 compass, 2 flashlight, 1 whistle, and 1 rope as well as other necessary items specific to the climate and region where the lost individual is. Once it reaches the individual the container will be automatically opened.	A container will be designed that can be attached to the search and rescue vehicle. It will be tested to ensure it can fit all the necessary items mentioned while also having extra storage for any items the lost individuals have with them. It will go through terrain tests to ensure the container does not fall off or open. It has now been designed to open automatically with sturdy materials to ensure animals do not break it. The earliest test point was during prototyping as we threw just the storage container onto the ground multiple times without breaking. The last test point was when the storage was attached to the cart and was tossed around.
Functional, Interface	The safety vehicle will be equipped with a GPS tracking system that will notify nearby Emergency Services of its location at all times. It will also have speakers that can be activated by the lost individual or by the Rescue Team that will release a sound notifying nearby search teams of the vehicle's location. Once the vehicle finds the lost individual, it will automatically notify the search and rescue teams and emergency services.	To validate these features the vehicle will be placed in multiple hard to reach areas where it will usually be deployed (mountains, deserts, forests, etc.). There the GPS features will be tested to ensure it is accurately showing the vehicle's precise location. “Practice runs” will also take place during testing to ensure the vehicle is able to identify the lost individual and stop where they are. The speakers will also be activated with people standing certain distances away to ensure it can clearly be heard. The testing can begin during the design phase when we are looking for the best devices (GPS, speakers, etc.). This was ultimately omitted due to time constraints and lack of materials.
Economic, Regulatory	The vehicle's design must be cost effective and meet the budget placed by the Government of Ontario and Engineering Firm. The materials used can not be expensive while also ensuring the vehicle functions as desired. It will have to remain durable enough to survive obstacles and animal encounters while	Calculations on the max stress and strains applicable to the chosen materials will be conducted to ensure it can survive damage. Physical tests will also be conducted where the vehicle is hit and dropped to see how it is affected or deforms. In depth calculations and tracking on the material spendings for the device will be done before beginning

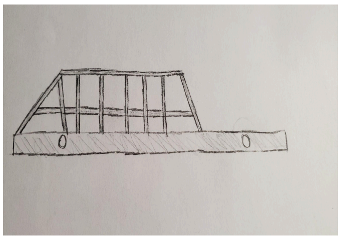
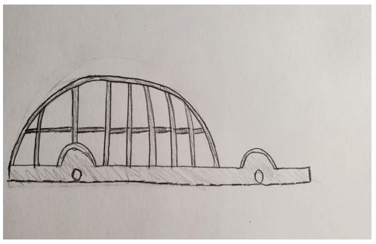
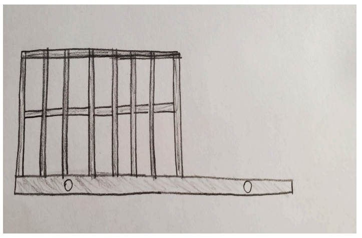
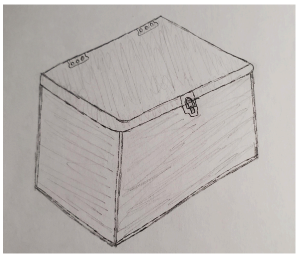
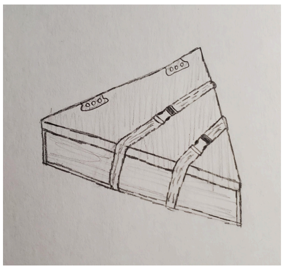
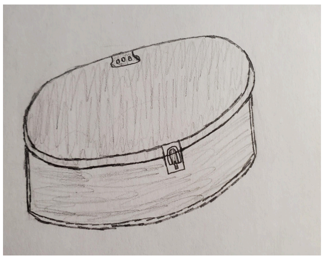
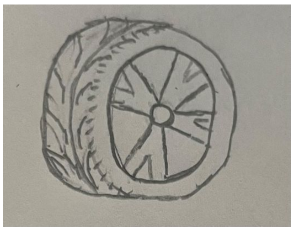
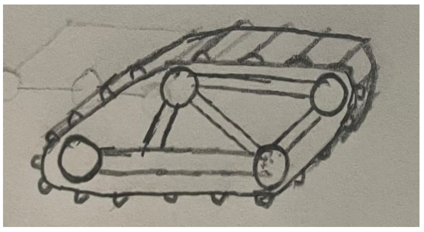
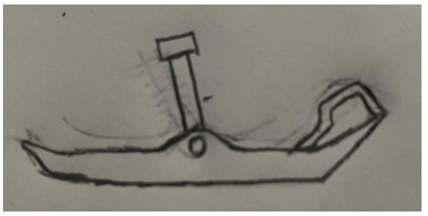
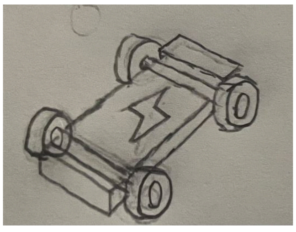
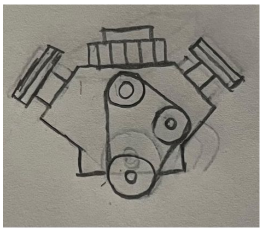
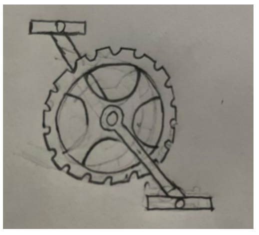
	searching. The communication devices must also be kept safe and function properly at far distances. Making the vehicle cost effective can make it easier to produce more if the design is approved. This will decrease the number of people needed to be sent to search and help find the missing individuals faster.	production to ensure the team stays within budget. The earliest testing and calculations can begin during the design phase as the materials and costs will affect the vehicle's design. The latest durability testing can begin after the design phase with prototypes of the vehicle. Testing is still being conducted beyond the design phase as long term results have not been discovered yet.
Functional	The design of the search and rescue vehicle must be able to traverse any terrain and obstacles it can encounter. The vehicle will have All-Terrain wheels with a flexible suspension system to allow it to go over small objects. The structural materials will be durable enough to survive falls and animal attacks. In the case the vehicle reaches an obstacle it can not pass, it must be able to find another route. It will also need a strong and long lasting battery to maximize the distance and time it can search.	The vehicle will go through different terrain tests to see how fast and easily it can move. Obstacles will also be placed in front to examine how it goes over and moves around if needed. It will also be dropped from multiple different heights as well as being hit by rocks and other objects to test its durability. The vehicle will be put to run for as long as it can to test its battery life and determine the maximum distance it can travel. The testing can begin during the design phase as we test different wheels and materials to choose. The latest testing can begin once prototypes have been built.

(Table 2: Requirements Table)

1.3) Functional Structure Diagram and Morphological Chart



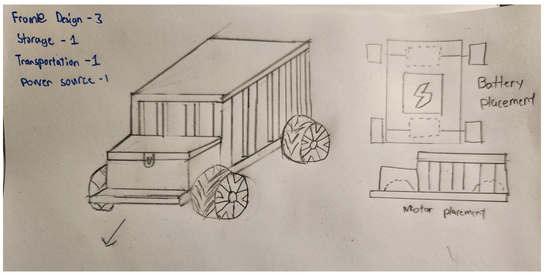
(Figure 1: Function Structure Diagram)

	Option 1	Option 2	Option 3
Frame Design			
Storage			
Method of Contact with Ground			
Power Source			

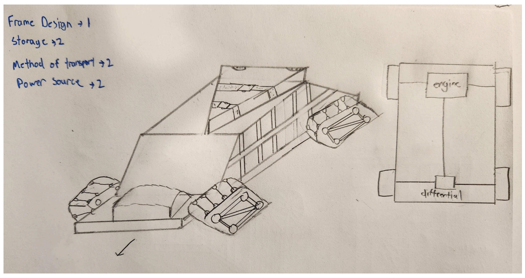
(Table 3: Morphological Chart)

One thing we realized about our morphological chart after we finished our conceptual design report is that we could have had a different option instead of the power source option. This was due to our oversight that we were going to be provided a battery and a motor that would be powered by electricity. This could have been replaced by a suspension type or chassis shape, which would have provided us with more detailed and complex designs.

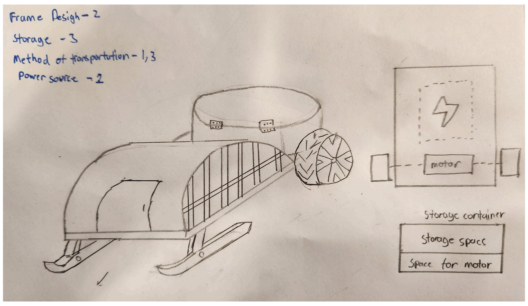
1.4) Conceptual Design Choice



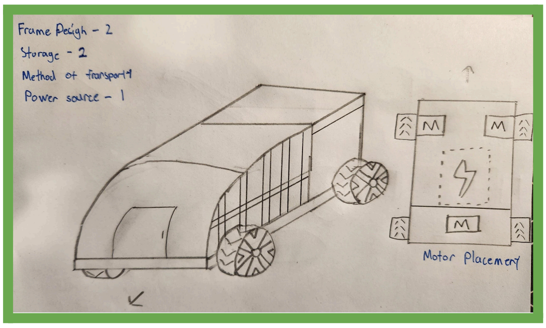
(Figure 2: Design Concept 1)



(Figure 3: Design Concept 2)



(Figure 4: Design Concept 3)



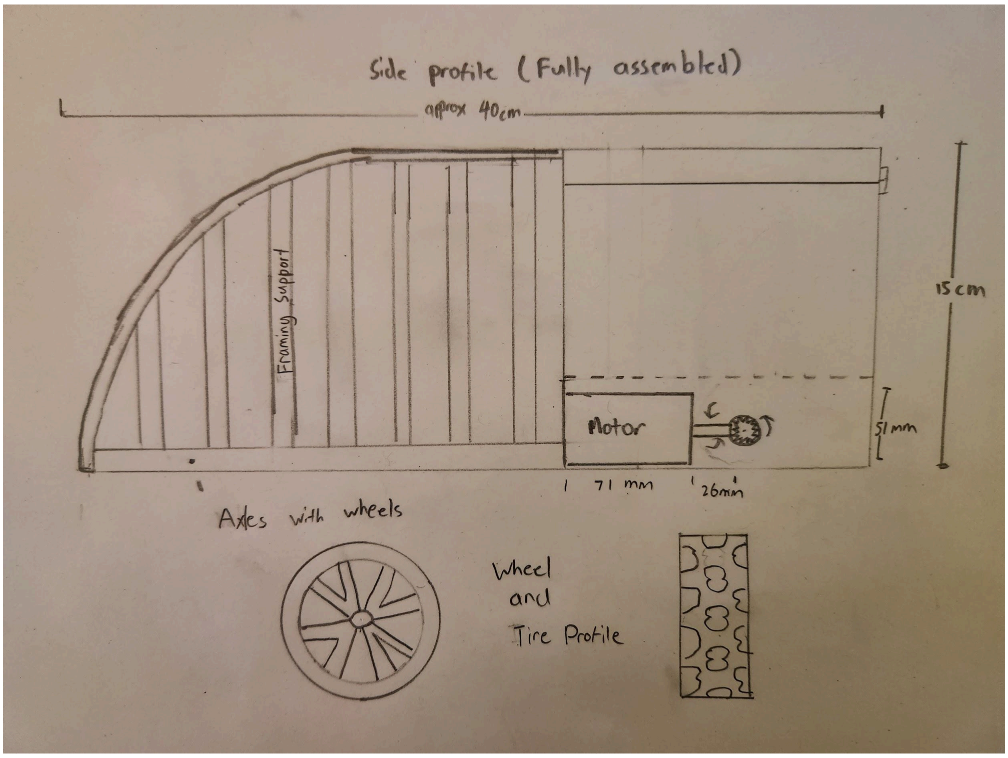
(Figure 5: Design Concept 4)

From the morphological chart, we deduced 4 designs that seemed viable for the problem we proposed. We found that our 4th design fits all our requirements with a weight of 9/10 compared to the other three designs. Its rounded design allows it to be more energy efficient due to its aerodynamic profile, and the storage container is not irregular in shape to maximize storage potential. Our final design does reflect the 9/10 rating with the requirements since the design remains mostly unchanged. The most we changed from the initial design is that we made the rounded part steeper and the frame became a shell. There is also added length and the ability for it to detach into two parts. The reason for it still being at 9/10 however is due to the fact that it doesn't allow for steering. This is because the axle goes through the body of the vehicle as one rod. Although we proposed that we would machine the chassis from aluminum, it seemed impossible for the clipping mechanism to be implemented without adding parts by sticking it on, causing possible critical areas.

Out of the other three designs, we did think that 2 of the designs could have worked since we did rank them as 7/10 in terms of fulfilling our requirements. The design that looked like a jeep was relatively the same as the one we selected. It might have been even safer because the storage was in front instead of the back. This would have not only protected the victim from oncoming obstacles, it would have made the car front-wheel drive, which can climb inclines much more easily. The design with tracks had less potential of being chosen but still could work. We could have replaced the engine with the battery just making it electrically driven/ The car was also lower to the ground making it easy for victims to get on. The largest factor in us not choosing it was the treads, which would have taken a lot of prototyping to make.

Section 2: Embodiment Design

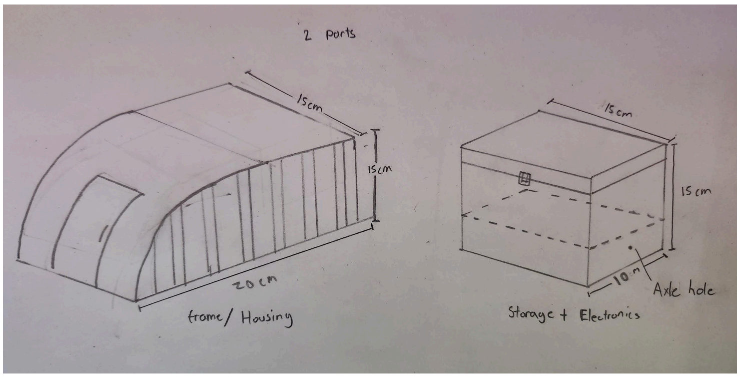
2.1) Preliminary Design



(Figure 6: Preliminary Design)

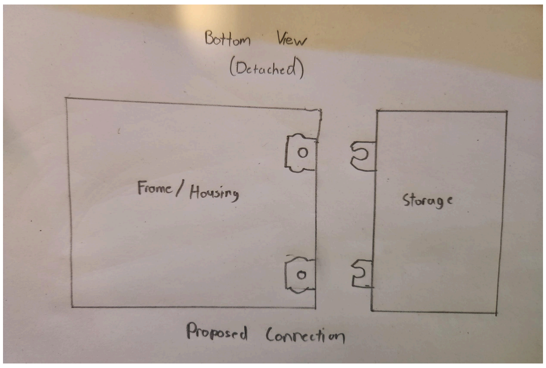
Most features from our preliminary designs have not changed from our embodiment design report. The shape and layout remain the same apart from the motor being slightly lowered, part of the motor will be sticking out the bottom of the frame, this decision was made to conserve space so we can fit electronics and other components. The front area angles have come a bit steeper to make it more rigid. Making it more resilient to buckling will ensure the safety of passengers and the reusability of the vehicle. Most of the electronics will be stored underneath the storage compartment to make more room for the passenger and to have a safer weight distribution. The dotted line represents an access panel to ensure maintenance can be conducted.

The axle placement has also been lowered slightly alongside the motor, this allows for the vehicle to traverse along slopes easily. The wheel design has remained the same using rubber to provide better traction for smooth surfaces and rough terrain.



(Figure 7: Vehicle Part Designs)

We plan to 3D print most of our components due to ease of access. This includes the Frame/Housing, storage container, the connectors that would attach the parts mentioned above, and bindings to keep components like the motor in place. The two main components will be 3D printed with a way to attach and detach them to fit project constraints.



(Figure 8: Connection Design)

Parts such as the wheel rims and the axles will not be 3D-printed. Due to those parts taking most of the force inflicted from the ground, they must be sturdy like an actual automobile. Initially, in our embodiment design, we were going to make our wheel rims through the machine shop but due to time constraints, we decided to buy them from a retailer. We also intend to buy tires. These will be sourced from a hobby shop or a retailer that specializes in remote control buggies. Two main factors in this decision were that if it were printed from PLA, it would slip on inclines and our limitations as designers. Designing tires is complex and a field we are all not familiar with. Buying tires would ensure their quality and performance.

This is an RWD vehicle meaning most of the weight is concentrated in the back of the vehicle. To ensure the vehicle doesn't tip over we designed the front housing of the vehicle to be longer. This added to the fact that the passenger also sits in the front will bring some of the load from the storage box to the front. For our planned prototype demonstration we plan to put most, if not all of the weight in the front housing.

2.2) Design Calculations

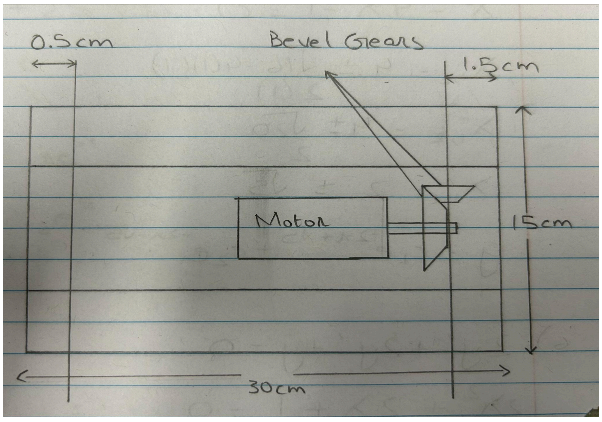
Our team decided that all of the design calculations from the embodiment design would not be changed. We agreed that all of the calculations conducted were done correctly and necessary. Some new design calculations were determining the diameter and circular pitch of the gears, axle torques, and output RPMs. These new calculations helped to better understand the forces acting on the gears and were used in the creation of our final design.

Strength Calculations:

Material	Yield Strength (MPa)	Young's Modulus (GPa)
Fiberboard Sheet	24.0	4.00
Low-carbon steel rods	180	213
Stainless steel hex screws and hex nuts	671	0.196
Rubber Bands	27.6	0.00127

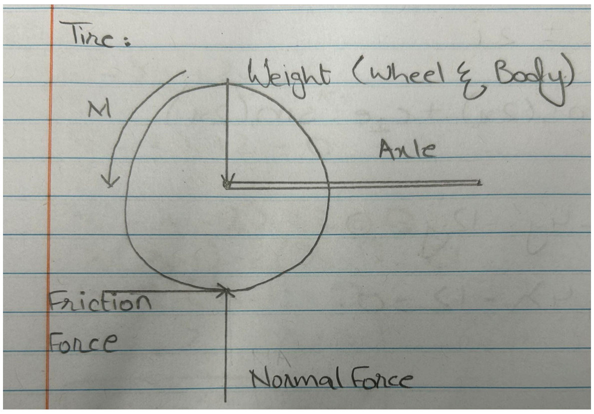
(Table 4: Strength Calculations)

Chassis FBD:



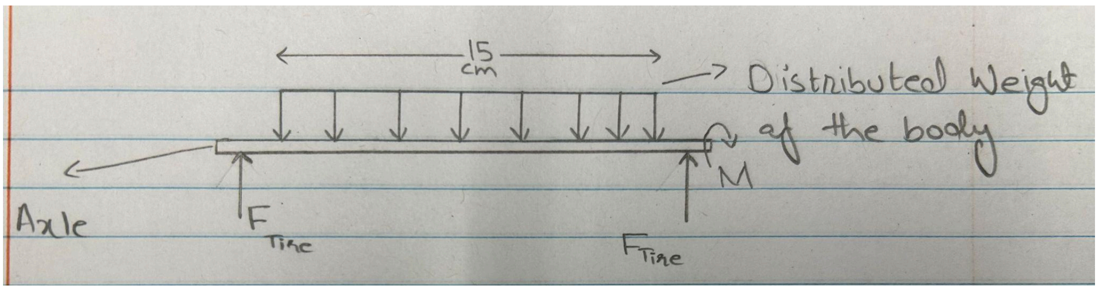
(Figure 9: Chassis FBD)

Tires FBD:



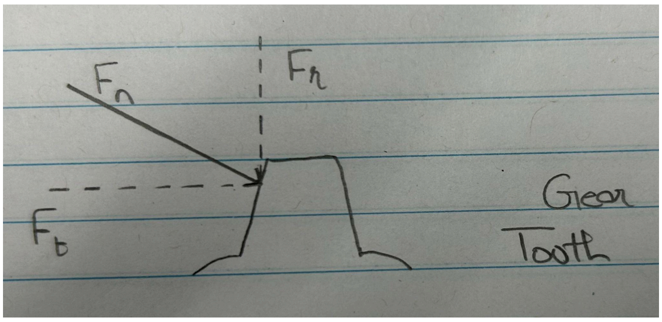
(Figure 10: Tires FBD)

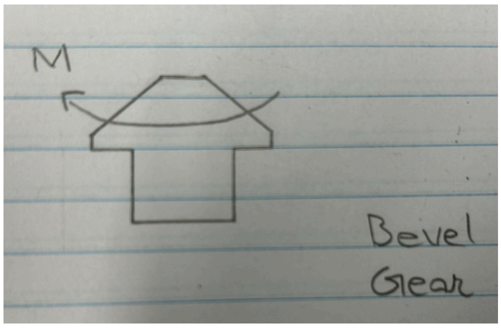
Force and Moment on Axle FBD:



(Figure 11: Force and Moment on Axle FBD)

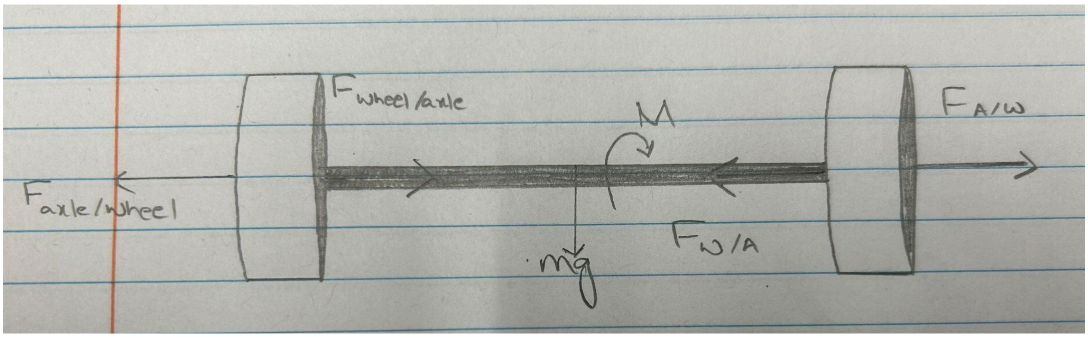
Gear Moment and Force FBD:





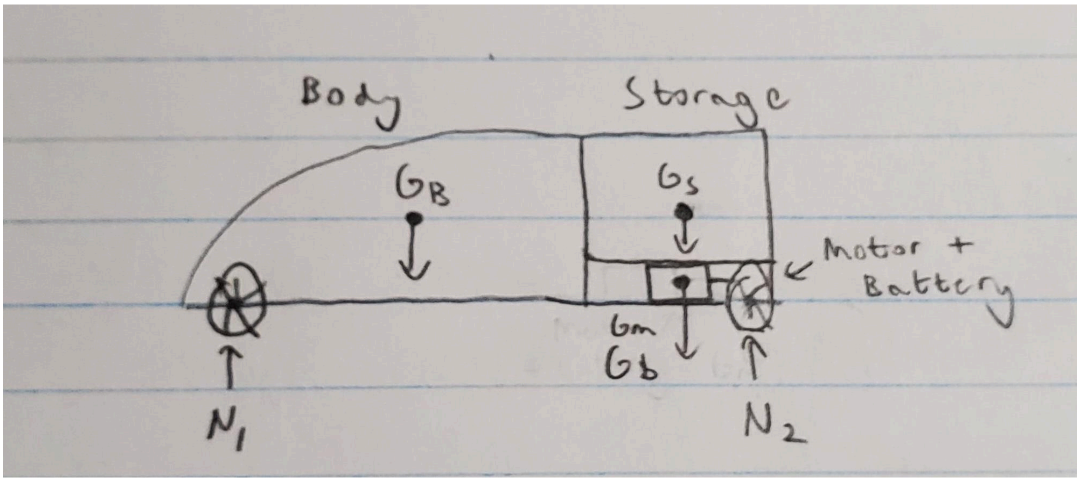
(Figure 12: Gear Moment and Force FBD)

Reaction Forces and Moment on Axle and Wheel:

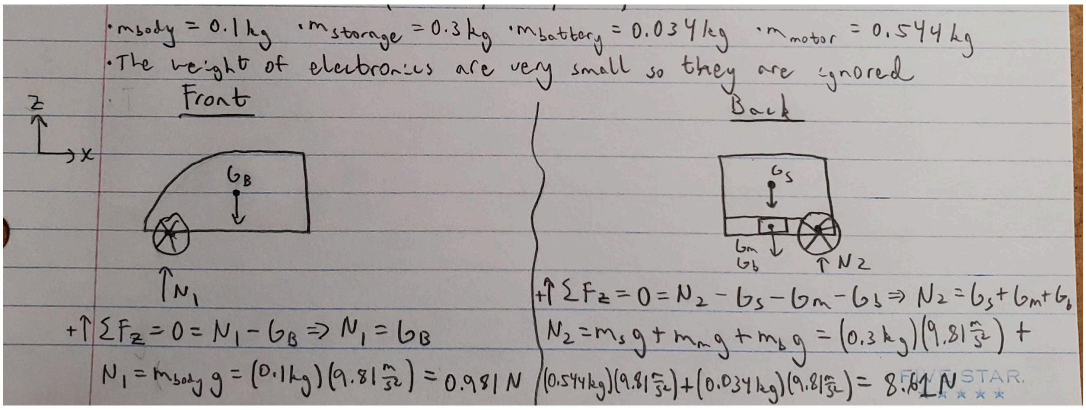


(Figure 13: Reaction Forces and Moment on Axle and Wheel)

Normal Forces Acting on the Wheels:

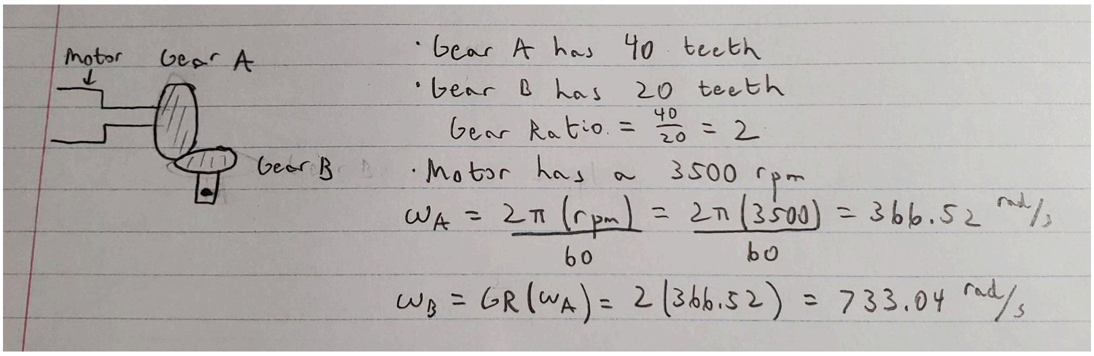


(Figure 14: Vehicle FBD)



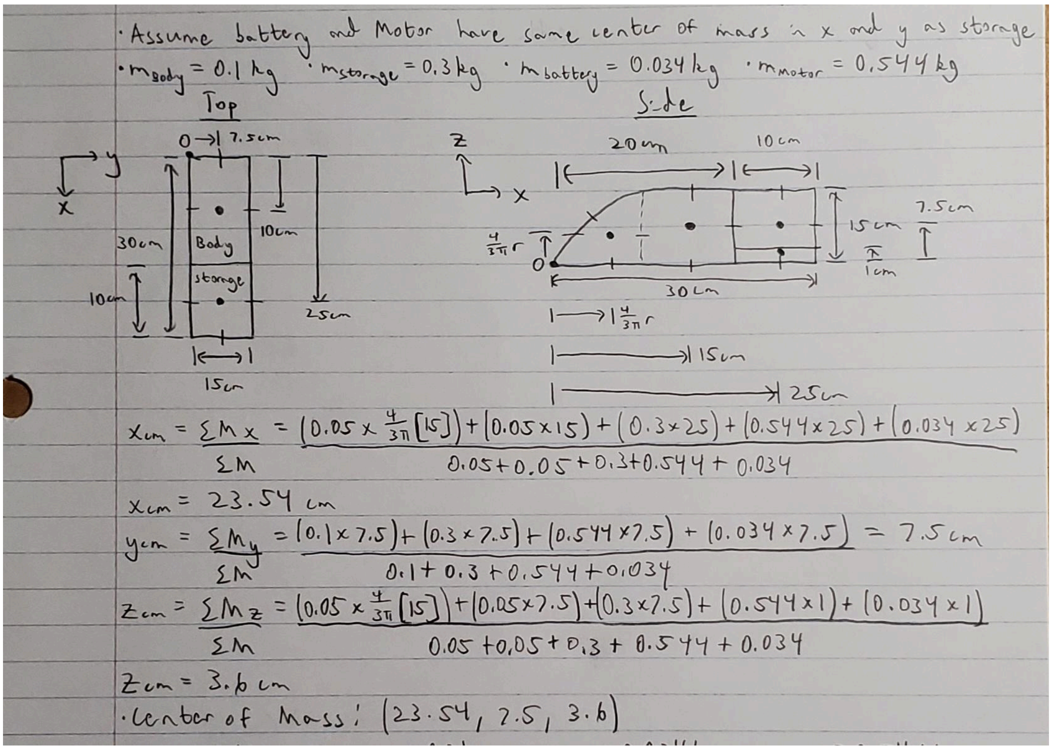
(Figure 15: Normal Forces Acting on the Wheels)

Bevel Gear Angular Velocities:



(Figure 16: Bevel Gear Angular Velocities)

Center of Mass:



(Figure 17: Center of Mass)

Axle:

Assuming the weight of the axle is 200g with a diameter of 5mm and covered length of 4cm. 2 wheels, each of weight 100g. So,
Stress = F/A
Stress = ((0.2+0.1+0.1) x 9.81) / (0.005x0.04)
Stress = 19,620 KPa
Stress = **19.62 MPa**, which is less than the yield strength

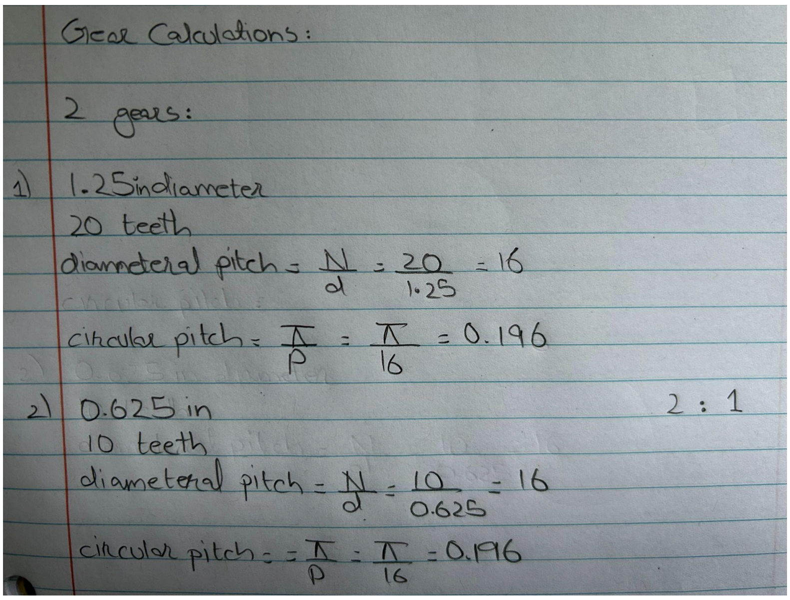
Gears:

There are going to be 2 gears, low and high. 1 gear is attached to the axle and there is going to be a choice between 2 gears on the Motor. The ratio between the gears on the motor and on the axle is going to be **1:1** and **1.5:1**. Where 1.5:1 is the high gear.
Low gear is going to have an RPM of **3,500** and high is going to have an RPM of **5,250**.

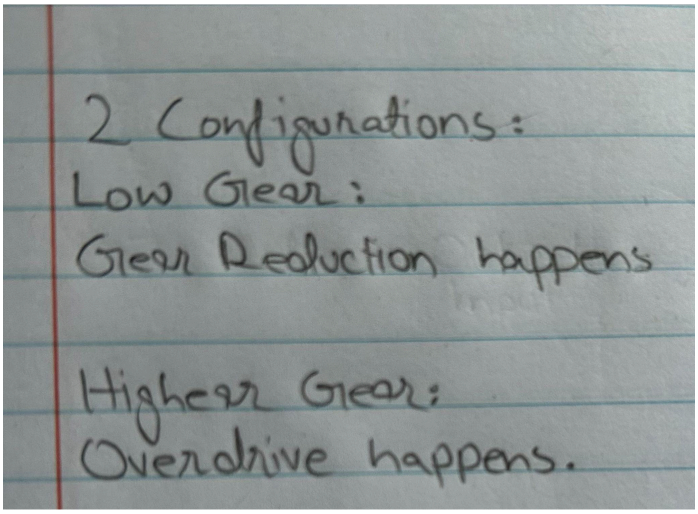
Wheels:

The whole weight of the vehicle is going to be around 1.5 - 2 kg with an additional capacity of 1 - 1.5 kg. There are 4 tires so the load is going to be divided between them. A wheel is 2 cm thick with a diameter of 9cm

Stress = (3x9.81) / (0.02x0.09)
Stress = 16,350 KPa
Stress = **16.35MPa**



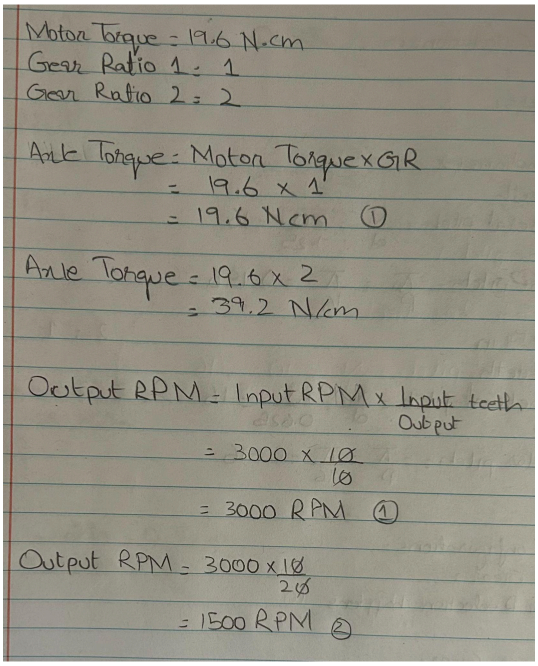
(Figure 18: Gear Pitch)



2 Configurations:
Low Gear:
Gear Reduction happens

Higher Gear:
Overdrive happens.

(Figure 19: Speed Configurations)



Motor Torque = 19.6 N.cm
Gear Ratio 1 = 1
Gear Ratio 2 = 2

Axle Torque = Motor Torque × GR
= 19.6 × 1
= 19.6 Ncm ①

Axle Torque = 19.6 × 2
= 39.2 N/cm

Output RPM = Input RPM × $\frac{\text{Input teeth}}{\text{Output}}$
= 3000 × $\frac{10}{10}$
= 3000 RPM ①

Output RPM = 3000 × $\frac{10}{20}$
= 1500 RPM ②

(Figure 20: Axle Torque and Output RPM)

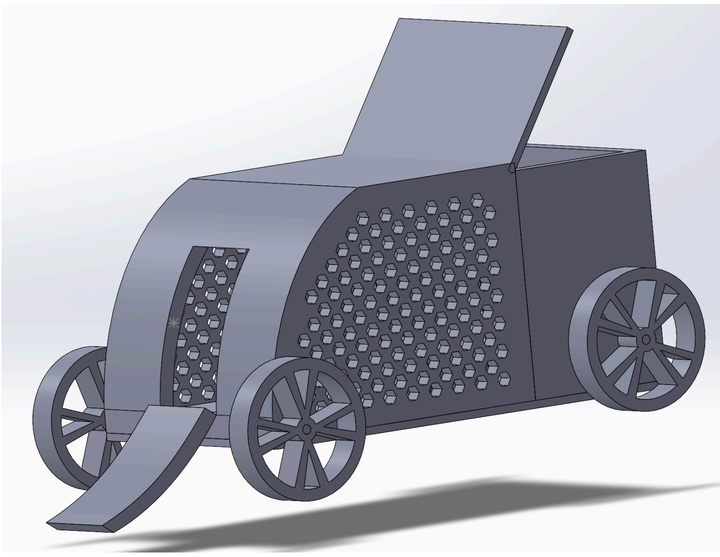
2.3) Risk Assessment

When developing the vehicle it is important to consider all the risks to ensure the safety of the passenger and the longevity of the vehicle. Mechanical risks include gears and other moving parts as they can be hazardous to the passenger or while performing maintenance while exposed. To limit this risk the gearbox and other moving components will be hidden underneath the storage compartment and the storage compartment will be removable for easy access. Our vehicle will be in rough terrain and adverse weather conditions for most of its deployments so there's a serious risk of the outdoor elements damaging the vehicle compromising the safety of the passengers.

To mitigate this risk our team chose plywood for the chassis as it offers strength and flexibility. We've thoroughly tested the chassis to ensure it can handle the weight of the vehicle and withstand any impacts while maintaining structural integrity. These tests include placing objects like rocks or sticks on the exterior of the car to test its durability. conducting drop tests of around 1 metre to ensure the wheels and axles can withstand the impact. The vehicle was also driven over various terrains like rocks, glass, and dirt to test its maneuverability. Since our storage container is detachable the risk of it detaching while moving was considered during the embodiment phase. To prevent this from happening we have clips on the bottom that attach to the frame of the vehicle. To test if it would remain attached we applied forces from different angles and tied weights to the back this also tested how much weight the vehicle could pull.

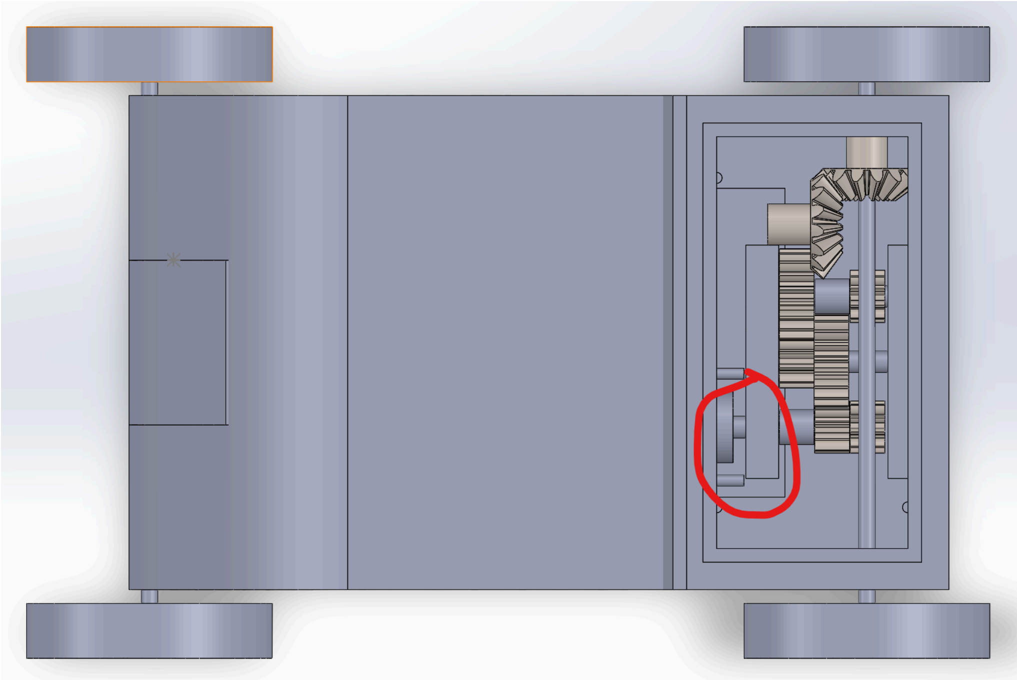
Section 3: Detail Design, Testing and Evaluation

3.1) Description of Final Design:



(Figure 21: Final Design CAD)

Our final design is made up of two components which serve different purposes. The front half of the design is where the electronics and sensors are placed. These include the Arduino Uno wifi-board, Obstacle Avoidance Module, IR Receiver, Remote Control Transmitter, and LED's. (describe how they are connected and work together as well as how it detects people). These components are surrounded by a frame that will protect them from damage if the vehicle falls or hits obstacles. The second component is the back half of the vehicle which is detachable. This will ensure the vehicle can fit within the required size constraints while still maintaining all of its necessary functions. This section will store the mechanical components. The XD3420 Dual ball bearing DC 12V Motor will be powered by a 9V Lithium Ion Battery.



(Figure 22: Final Design Gearbox CAD)

The Motor is connected to a dual-speed gearbox that is manually changed. This will allow the vehicle to reach higher speeds than with a standard gearbox. The start of the gearbox is connected to the Motor and has two small gears. With the first speed setting, one of the small gears makes contact with a large gear which is in contact with another small gear. The final small gear is attached to a rod that connects to the rear wheel axle by a bevel gearbox. To change the vehicle's speed, the middle rod is moved upward. The other small gear attached to the motor makes contact with the same large gear from the first speed. The difference now is that the large gear is no longer in contact with any other gear. Attached to the middle gear next to the large gear is a small gear. This gear will spin with the rod and make contact with a large gear on the rod transferring speed to the rear axle. Above these components is the storage box which will be used to store the necessary first aid and rescue items for when the vehicle finds a missing person.

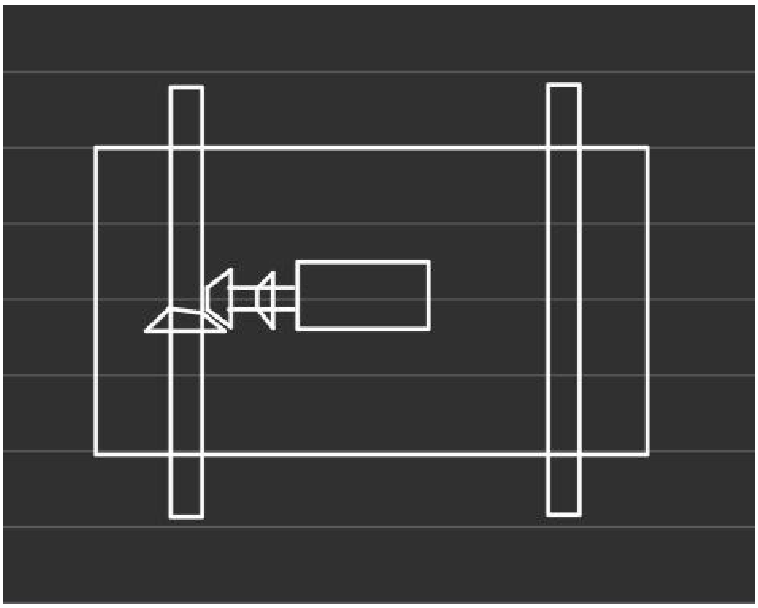
One of the few challenges we had with modeling was that we had two people work on two different crucial parts. The first is the chassis and body of the vehicle and the other is the gears, motor, and gearbox. With minimal communication about dimensions, we had to tweak the design multiple times due to things not lining up or just not fitting at all. This is one of the reasons why the back axle is so high in the design now. There is now also a hole through the back wall of the frame and storage compartment to house the motor as it was the only way for it to fit to achieve a balanced weight.

3.2) Prototype Testing and Results:

In our mini-design project, we focused on developing and testing various critical components of our prototype. One of the main elements was the gearbox. Initially, our design featured a three-bevel gear system, with one gear on the axle and two on the motor shaft, aiming to efficiently transfer power from the motor to the wheels. During early tests using Lego pieces to model our design, we encountered significant challenges with gear shifting. This led to a complete redesign of the gearbox to address the mechanical complexities and inefficiencies we faced, aiming for smoother operation. The gears did not provide the necessary speed because the gear ratios were not optimal for our prototype's torque and operational requirements. Additionally, the alignment and spacing of the gears caused increased friction and resistance, further reducing efficiency.

This led us to revisit and redesign the gearbox. We focused on optimizing the gear ratios and adjusting the physical arrangement of the gears to minimize friction and improve overall power transmission. Initially, we planned to control the gearbox with an Arduino system, but after reevaluating our needs and the challenges of integrating Arduino controls, we switched to a simpler joystick control. This adjustment made the control system more straightforward and reduced potential issues during operation.

For the chassis, we chose plywood because of its strength, availability, and ease of handling. We tested extensively to ensure it could support not only the prototype's base weight but also the additional load from other components that would be added later. This testing was essential to verify that the plywood could meet the weight requirements and handle the operational stress.



(Figure 23: Bevel Gear Design)

3.3) Project Reflection and Evaluation:

During the Conceptual Design phase, our team believes that we did not make any mistakes in the selection of the requirements and objectives of our vehicle. As a search and rescue vehicle, our design must be strong and durable to survive collisions, falling, animals, and other unexpected obstacles in their search. This is why we placed all of the electrical and mechanical components on the bottom frame as well as adding protective frames on top. This helps ensure the vehicle does not break down and get lost. The design also possesses aerodynamic features that will allow the vehicle to travel through windy regions (such as deserts or mountains) easily.

Our team does believe that Proposal Designs One and Two would have also worked. This is because these designs still met the required design objectives. They had strong frames positioned and designed to protect the mechanical and electrical components from obstacles. Both also had space for a storage box to be placed without going over the dimension requirements. The only issue with proposal design two was the chosen wheels which had a tracked treads design. This design is not very efficient for terrain traversal which would have hindered the vehicle. Proposal design number three would not have worked due to its design not leaving enough space for all required components as well as having skis instead of wheels at the front of the vehicle. This would make it only viable for smooth terrains such as snow and sand which goes against the vehicle's purpose of being all-terrain.

To help protect the vehicle further we made the requirement to install an obstacle detection system. This detection system will additionally identify individuals and promptly alert search and rescue teams as well as emergency services to facilitate their rescue. Another requirement was incorporating a speaker system into the final design that could be used to notify nearby search and rescue teams and missing people of the vehicle's location.

A requirement that was not implemented into our final design was a suspension system and a built-in GPS due to the complexity of designing and creating these systems as well as being too time-consuming. Not implementing the suspension system will make it more challenging for the vehicle to navigate obstacles, but the selected wheels were specifically engineered to handle various terrains with ease. Due to these changes, the selected conceptual design was different from the chosen final design.

3.3) Project Reflection and Evaluation (Continued):

From our final design, the gearbox was the most important aspect to analyze as it was the most complex and had a massive impact on the vehicle's performance. Ensuring there were minimal flaws with our design was a priority for our team. As mentioned earlier we encountered issues with shifting gears which led to a complete redesign of the gearbox, which included revisiting the calculations related to the gears. After performing tests, we would refine and adjust our calculations to ensure components were working as expected. No key aspects or design calculations were overlooked.

After gaining experience with materials, fabrication, and assembly we realized we had to make a few changes relating to our design. Initially, we intended to use the workshop to build our chassis from metal, however, we overlooked the weight and the complexity of assembling the component, So we opted to use plywood due to its strength, availability, and ease of handling. Other components such as the frame/housing and storage containers will still be 3D-printed. Testing our design proved to be challenging due to several factors such as the strike and time constraints which made it difficult to organize as a group. This alongside the complexity of the gearbox made it difficult to test the performance of our design effectively.

Our initial prototype didn't perform as expected due to issues with gear shifting, which led to us redesigning it focusing on optimizing gear ratios and physical arrangements. However, due to the strike and time constraints, it made it difficult to perfect our gearbox design for our prototype. If we had spent more time modeling and analyzing our design, it would have helped us fix most issues before building it, saving us more time in the long run and improving our prototype's overall performance. Our gearbox proved to be the most challenging aspect of our design so spending more time reanalyzing it, could have helped us avoid future problems with testing our prototype as well as improving performance.

Conclusion:

In our design course, the complexity increased significantly compared to our earlier coursework, starting with the Conceptual Design phase which initiated our project's development. However, we encountered major challenges during the Embodiment Design phase, which were intensified by an unexpected strike. This strike caused confusion and mismanagement, disrupting our ability to coordinate effectively and complicating technical tasks such as optimizing the gear transmission for our prototype.

Due to the strike, classes were canceled and roadblocks prevented team members from accessing campus, forcing us to shift our meetings online. While this allowed us to continue our project, the remote setup hindered our ability to perform crucial hands-on tasks like designing and testing the prototype effectively.

As a result, our prototype development was not successful, which in turn negatively affected our Final Design. These issues highlighted the importance of adaptability and strong project management, especially when facing unexpected external challenges.

In our project, we aimed to cover all essential components and successfully completed most of them. Our primary goal was to design a solution that assists people in unfortunate situations, a target we achieved. This accomplishment marked a significant achievement for our team.

However, we recognize that our project would have benefited from additional testing and trials. More comprehensive testing would have allowed us to identify and address operational issues more effectively, enhancing our calculations and improving our handling of any discovered shortcomings. Such detailed testing would have improved the design's overall effectiveness and reliability, ensuring it not only meets but surpasses the needs of those it is designed to help.

Appendices:

Appendix A: Arduino IDE Codes

[RC_Car.ino]

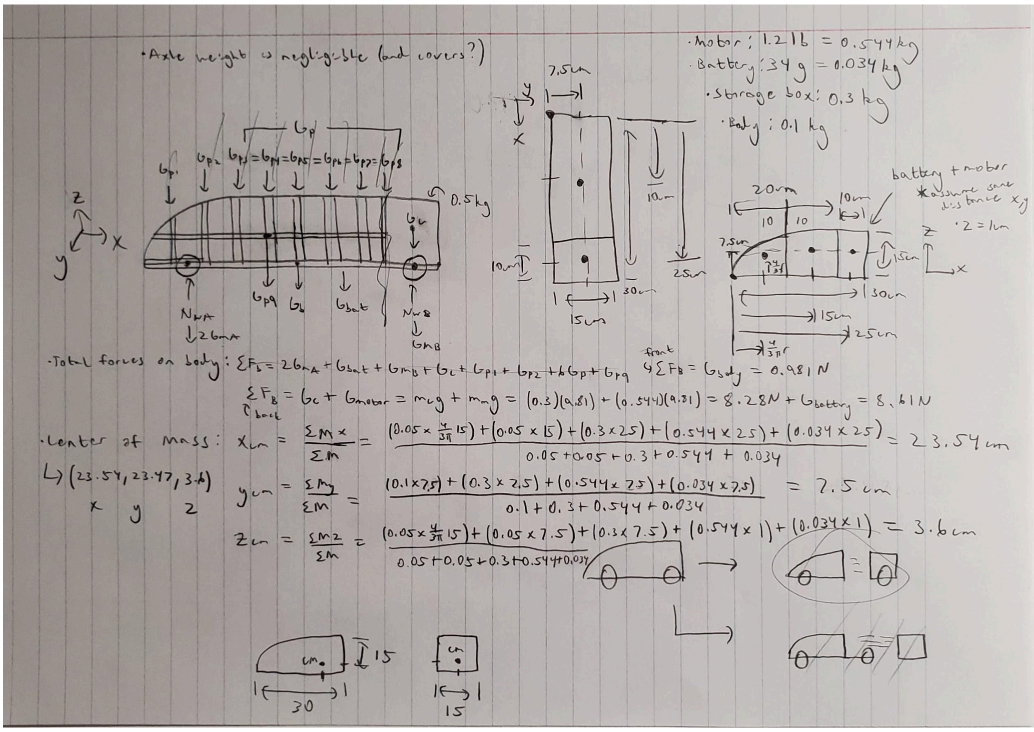
Appendix B: Bill of Materials (BOM)

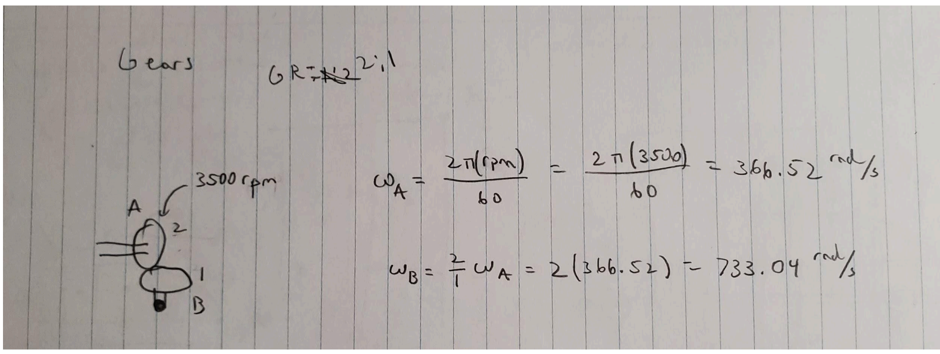
Item	Description	Supplier	Part #	Link to Store	Quantity	Cost
1	XD3420 Dual ball bearing DC 12V Motor	York University			1	$0
3	9V Lithium Ion Battery	York University			1	$0
4	Low Carbon Steel Rod	York University			2	$0
5	Arduino Uno wifi-board	York University			1	$0
6	Obstacle Avoidance Module	York University			1	$0
7	IR Receiver	York University			1	$0
8	Remote Control Transmitter	York University			1	$0
9	LED's	York University			1	$0
10	Battery Clip	York University			1	$0

Meeting Minutes:

Date:	How Long?	About?	Attendance	Where?
03/25/2024	3 hours	Confirmation and furthering the design	Everyone	Scott Library
03/28/2024	2 hours	Splitting up work and handing parts off	Everyone	Scott Library
04/05/2024	1 Hour	Confirmation of work done, and how to finish project up	Everyone	Online Call

Appendix D: Hand Calculations





Appendix E: Design Logbooks

Date	Progress
02/13/2024	- Obtained main components of for the build of the project - Familiarized ourselves with the components and decided how we planned to use each one - Decided what parts goes home with which group members for optimal attendance and specialization
02/18/2024	- Beginning of a discussion of how to program the Arduino UNO - Dedicated two group members to handle the programming - Collaborated ideas to streamline the coding in case of sick group member
02/23/2024	- Held a group discussing to relearn how to use the hardware - Topics included how to use the breadboard, when to use resistors, how to operate a multimeter - Also discussed how we might produce the prototype - 3D printing and a bit of machining
02/28/2024	- Started discussion for the Embodiment Design Report - Decided how we are going to tackle it
03/01/2024	- Had questions about the gears which we wanted to ask in the tutorials - Gathered a list of questions for both the TA and other teams - Did research to find solutions to help with out problems
03/03/2024	- Began working on the embodiment design report and presentation - Split the work between each group member - Joseph: 1.0, 2.2, 2.5 - Syed: Video and 2.5 - Justin: 2.1, 2.3, 2.4 - Mian Muneeb Mahmood: 2.2, 2.5 - Abishan: Video and 2.4
03/08/2024	- Had concerns about how the gearbox is going to work and fit in - Spent ample time designing a solution for it
03/09/2024	- Started modeling of the definitive design - Contemplated changes to the frame and the structure of the kart - Decided to make the kart longer due to being able to disassemble and

	be put into 20x20x40cm box
03/11/2024	- Finished our calculations and 3D CAD models of our design - Began the predicted performance and finished it later in the day - Started to create an outline for the Embodiment Design Presentation
03/12/2024	- Added finishing touches to the Embodiment Design Report - Edited each group member's presentation video section together - Completed the Embodiment Design Presentation
03/25/2024	- Met up to conference about the more complex aspects of the cart - Finalized a design for the gearbox to start modeling and prototyping it - Started gathering the final report appendices - Official start date of the report
03/28/2024	- Split up work for the report - Handed parts off to each other to prototype and test - Report done about 25%
04/05/2024	- Report done about 60% - Had one another looks at each other sections to revise and add -
04/07/2024	- Coding was finished - Modeling and simulations was finished
04/13/2024	- Finishing touches on report - Final testing of prototype - Report progress 100%
04/14/2024	- Final look over and revision