Embodiment Design Presentation

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Project Background and Context

- Hiking has surged in popularity post-pandemic, resulting in an increase in injuries and missing persons cases.

- Ontario government has dispatched search and rescue teams, but their efforts are hindered by safety concerns and resource costs.

- An engineering firm has been hired to develop technology for locating missing individuals, while York University students are designing a search and rescue vehicle.

Objectives and Requirements

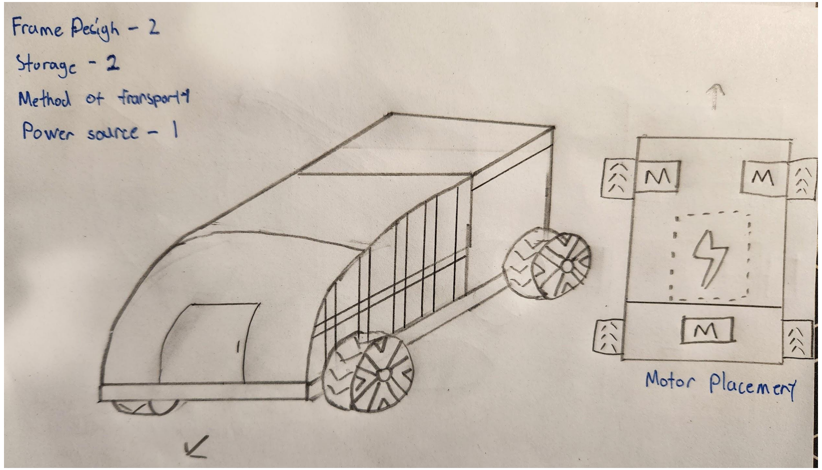
- The vehicle's design includes features like collision avoidance, control via arduino board, detachable storage, and sensors/GPS tracking to navigate obstacles. The aim is to efficiently locate missing persons in various terrains and save lives.

- A single-speed DC electric motor will be powered by a 12V Lithium-Ion battery.

- Components such as an Arduino board (e.g., Arduino Uno WiFi), an analog joystick module, and a motor driver module (e.g., L298N) will control the direction and speed of the DC motor.

Embodiment Design

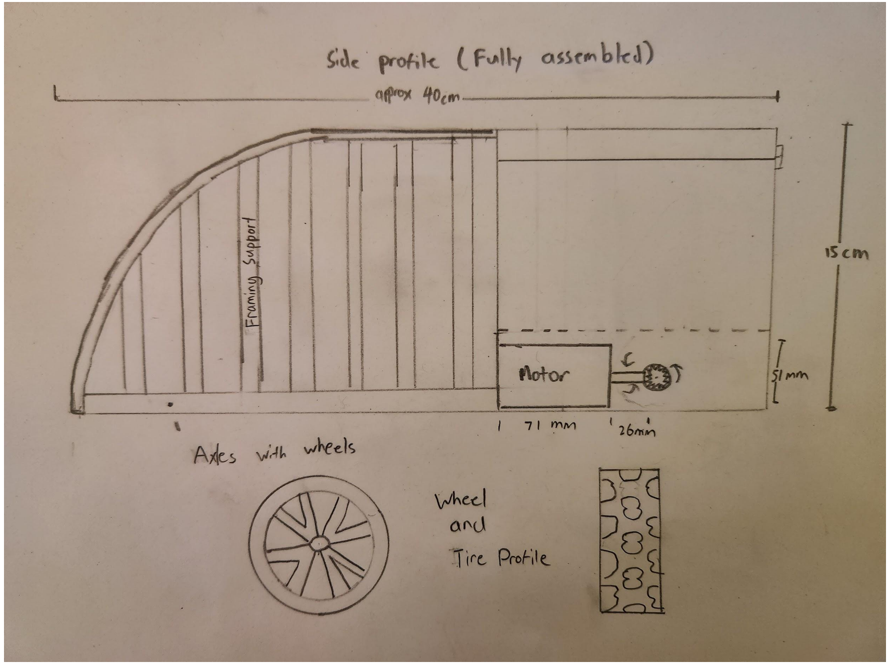
- Our design, which has progressed from the conceptual design phase, has undergone slight modifications. The primary goal was to maintain simplicity while moving forward
- Despite modifications, the shape and layout of the design remain consistent



Our Original Design from the Conceptual Design Phase.

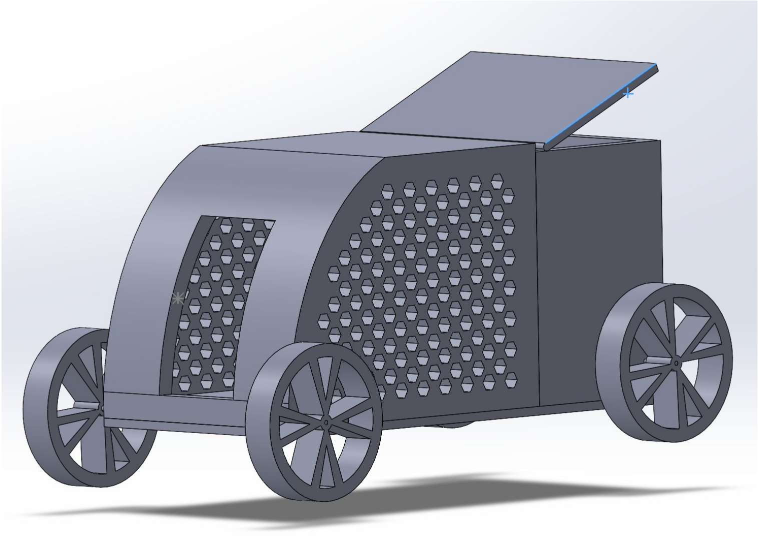
Embodiment Design

- The frontal angles have been adjusted to enhance rigidity, making the design more resistant to buckling, ensuring passenger safety
- Most, if not all, electronics will be housed beneath the storage container. This optimizes passenger space and contributes to safer weight distribution



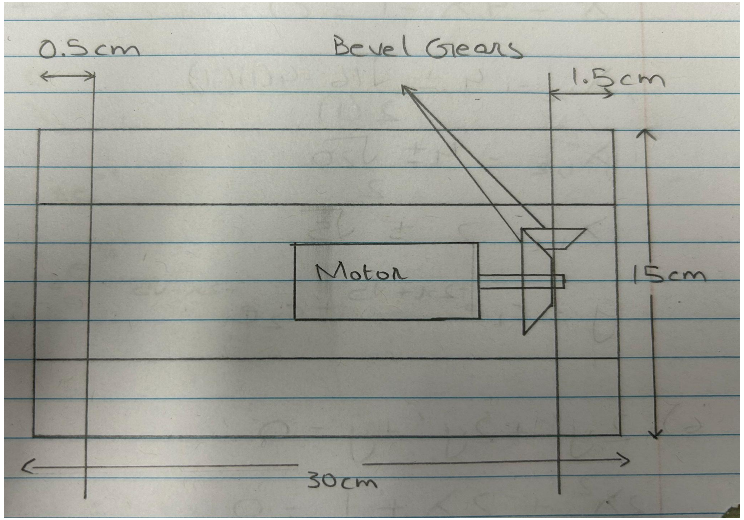
Embodiment Design

- An access panel beneath the proposed storage area allows for maintenance when the vehicle is emptied, ensuring efficient upkeep
- Certain parts, such as wheel rims and axles, are better suited to be bought from a machine shop as 3D-printed PLA may not be able to withstand the force from the ground
- We plan to buy the rubber tires to avoid slippage on inclines
- With a rear-wheel-drive design, we prioritize weight distribution



Design Calculations

Chassis FBD:

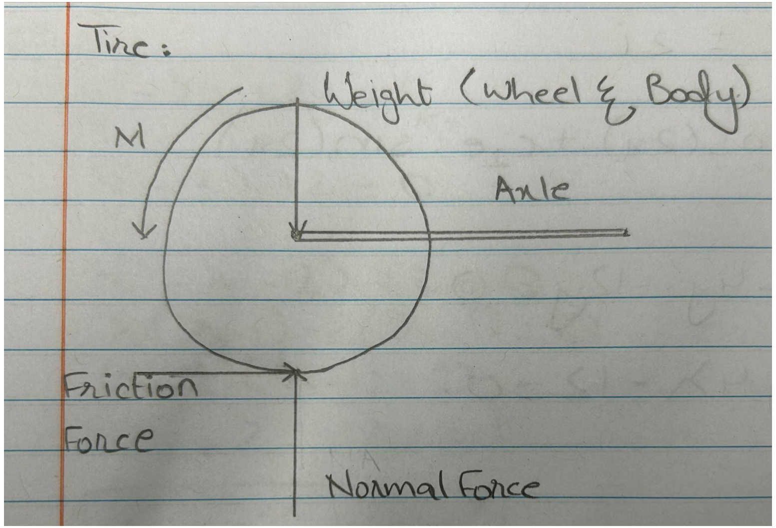


Strength Calculations:

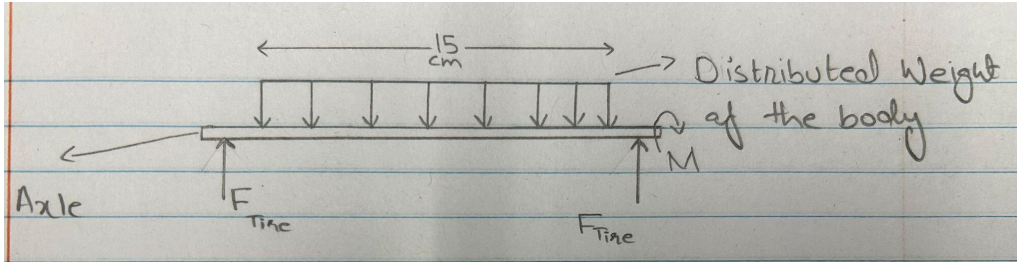
Material	Yield Strength (MPa)	Young's Modulus (GPa)
Fiberboard Sheet	24.0	4.00
Low-carbon steel rods	180	213
Stainless steel hex screws and hex nuts	671	0.196
Rubber Bands	27.6	0.00127

Design Calculations

Tires FBD:



Force and Moment on Axle FBD



Design Calculations

Calculations

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:

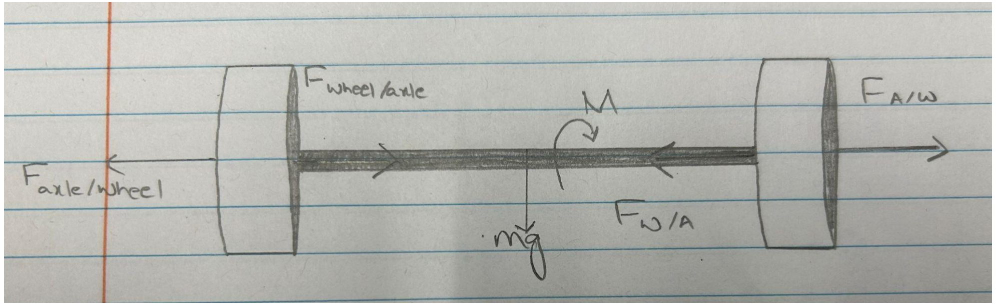
There are going to be 2 gears, low and high. 1 gear is attached to the axle and there is going to be a choice between 2 gears on the Motor. The ratio between the gears on the motor and on the axle is going to be **1:1** and **1.5:1**. Where 1.5:1 is the high gear.
Low gear is going to have an rpm of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

Reaction Forces and Moment on Axle and Wheel



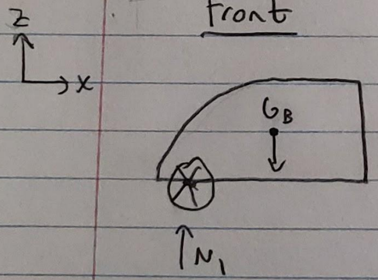
Design Calculations

Normal Force Acting on Wheels

• $m_{body} = 0.1\,kg$ • $m_{storage} = 0.3\,kg$ • $m_{battery} = 0.034\,kg$ • $m_{motor} = 0.544\,kg$

• The weight of electronics are very small so they are ignored

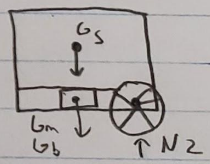
Front



$$+\uparrow \sum F_z = 0 = N_1 - G_B \Rightarrow N_1 = G_B$$

$$N_1 = m_{body}\, g = (0.1\,kg)(9.81\,\tfrac{m}{s^2}) = 0.981\,N$$

Back

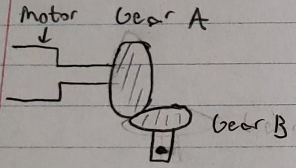


$$+\uparrow \sum F_z = 0 = N_2 - G_s - G_m - G_b \Rightarrow N_2 = G_s + G_m + G_b$$

$$N_2 = m_s g + m_m g + m_b g = (0.3\,kg)(9.81\,\tfrac{m}{s^2}) + (0.544\,kg)(9.81\,\tfrac{m}{s^2}) + (0.034\,kg)(9.81\,\tfrac{m}{s^2}) = 8.61\,N$$

Design Calculations

Speed of Gears:



- Gear A has 40 teeth
- Gear B has 20 teeth

Gear Ratio $= \frac{40}{20} = 2$

- Motor has a 3500 rpm

$$\omega_A = \frac{2\pi(rpm)}{60} = \frac{2\pi(3500)}{60} = 366.52 \text{ rad/s}$$

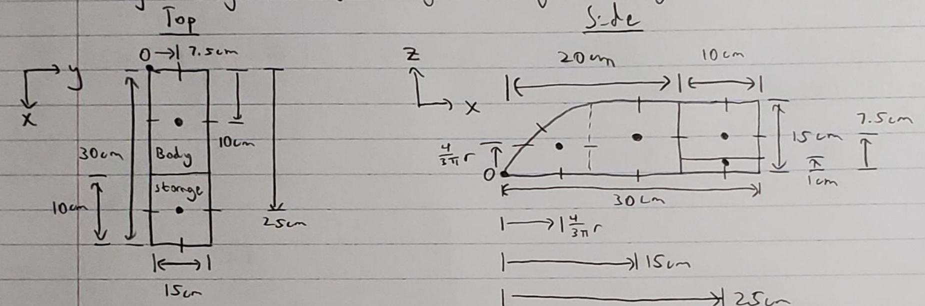
$$\omega_B = GR(\omega_A) = 2(366.52) = 733.04 \text{ rad/s}$$

Design Calculations

Centre of Mass:

· Assume battery and Motor have same center of mass in x and y as storage

· $m_{body} = 0.1\ kg$ · $m_{storage} = 0.3\ kg$ · $m_{battery} = 0.034\ kg$ · $m_{motor} = 0.544\ kg$



$$x_{cm} = \frac{\Sigma Mx}{\Sigma M} = \frac{\left(0.05 \times \frac{4}{3\pi}[15]\right) + (0.05 \times 15) + (0.3 \times 25) + (0.544 \times 25) + (0.034 \times 25)}{0.05 + 0.05 + 0.3 + 0.544 + 0.034}$$

$x_{cm} = 23.54$ cm

$$y_{cm} = \frac{\Sigma My}{\Sigma M} = \frac{(0.1 \times 7.5) + (0.3 \times 7.5) + (0.544 \times 7.5) + (0.034 \times 7.5)}{0.1 + 0.3 + 0.544 + 0.034} = 7.5\ cm$$

$$z_{cm} = \frac{\Sigma Mz}{\Sigma M} = \frac{\left(0.05 \times \frac{4}{3\pi}[15]\right) + (0.05 \times 7.5) + (0.3 \times 7.5) + (0.544 \times 1) + (0.034 \times 1)}{0.05 + 0.05 + 0.3 + 0.544 + 0.034}$$

$z_{cm} = 3.6$ cm

· Center of Mass: (23.54, 7.5, 3.6)

Prototyping

- Place objects (rocks, sticks) on the vehicle's exterior.
- Ensure it withstands force from objects weighing at least 3-4 kg.
- Verify that electrical and motor components remain secure during shaking and driving.
- Conduct drop tests to assess wheel and axle impact resistance.
- Test at a maximum height of approximately 1 meter.
- Drive the vehicle over various terrains (rocks, grass, dirt) to evaluate maneuverability.

Prototyping

- Ensure the back half (containing the storage box) does not detach or open while in motion.
- Apply force from multiple directions to test stability.
- Assess the vehicle's ability to carry required supplies and additional items.
- Drop the storage box from different heights.
- Attempt to forcefully pry it open.
- Verify that essential items remain secure and the box is resistant to animal interference.

Predicted Performance

- Our vehicle is designed for off-road terrain.
- Compact design (30cm x 15cm x 15.50cm) and large tires (9.00cm diameter) enable navigation through uneven terrain.
- Motor placement near the center and bottom ensures even weight distribution and a lower center of mass (23.54cm, 7.5cm, 3.6cm), enhancing stability.
- Calculations indicate the motor can provide sufficient force for inclined surfaces, and materials withstand external forces.

Predicted Performance

- Safely and comfortably transport passengers:
- Storage compartment (10.00cm x 15.00cm x 14.50cm) for medical supplies and motor.
- Passenger compartment (20.00cm x 15.00cm x 14.50cm).
- Chassis durability:
- Low-carbon steel rods and stainless steel hex screws/nuts with higher yield strength.
- Tested to withstand forces of 3-4 kg without internal damage.

Conclusion and Next Steps

- With our revised design we can confidently move on to creating our first prototype
- Some areas for further improvement could be found through in-field testing