



Thermoelectric Generator Challenge Project Report

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Executive summary

This report provides an overview of the design process of the thermoelectric vehicle that was built for the thermoelectric generator challenge in Thermodynamics II course.

The goal of this challenge was for the vehicle to roll across a distance of one meter on a flat surface before climbing a 36in long inclined plane of 20° to the marked top.

In order to accomplish this, a Peletier device was placed between a lighted candle and a heat sink, and the temperature difference allowed the device to provide a voltage to a motor that made the wheels turn. This resulted in a Carnot efficiency of 6.32%, resulting in a top speed of 0.0256 m/s and allowed the vehicle to climb to the top of the 36 inch, 20 degree slope.

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1. Introduction

The past two centuries have been extremely important in terms of technological advancements. Different methods of electricity generation continue to be developed today, and the already existing methods continue to be perfected to improve efficiency. Methods that use energies such as solar, wind, nuclear, etc. are popular electricity generation choices today. However, because sustainability is currently an important subject of today's reality, scientists are trying to turn to more sustainable methods. For this reason, thermoelectric generation is an interesting subject for students to explore because they are the future working-class [1].

In this Thermodynamics II course thermoelectric generator challenge, the objective was to design and build a small car that was only powered by a Peltier device that was placed between a lit-up candle and a heat sink and provided a voltage difference that was proportional to the difference in temperature of both sides. This voltage difference was to provide enough potential for a motor to run and propulse the car across a flat surface of one meter and up a 20° ramp. The Seebeck effect takes place when a temperature difference between two different conductive materials generates a voltage, because charge carriers move from the hot side to the cold side. A Peltier device uses this principle in reverse: when an electric current passes through it, heat is absorbed on one side and released on the other, creating a temperature difference. [2] The relationship between the voltage and the temperature difference is related by Seebeck effect equation:

$$V = S * \Delta T$$

Where V is the voltage in, S is the Seebeck coefficient and ΔT is the temperature difference.

In this report, the design and decision-making process will be described as well as the equations and thermodynamics theory that led to the final design.

2. Design and Construction

The goal of the design was to keep it as simple as possible and use the least number of parts.

Because a tea light was used for this project, the flame points upwards, therefore, it was obvious that the Peltier device and heat sink had to be placed at the top to maximize heat transfer. In addition to this, foam board panels covered with aluminum foil with holes were used to surround the candle to entrap the maximum heat and to allow for oxygen flow simultaneously.

As for the moving parts of the vehicle (motor, gears, wheels and axels), the wheels and axels had a locked rotation, and both axels were connected by a plastic rod. Because the rod was made of plastic, it had a low enough coefficient of friction that the axels had no trouble rotating and bearing weren't needed. The rear axle was driven by the motor which was connected to the Peltier device. To do so, a large gear with a 3mm inner diameter was press fitted on the motor output shaft and a smaller gear was press fitted onto the 2mm axle. This ratio created an overdrive mechanism because the axle rotated faster than the motor output velocity.

The vehicle body foam body was glued onto the plastic rod, and the motor and output gear were placed on the body platform in a way that the output gear was in contact with the axle gear.

2.1 CAD Design

Figure X shows a labelled SolidWorks CAD model of the vehicle. It details the integration of the chassis, the Peltier device, the motor, the heatsink and the axle with wheels.

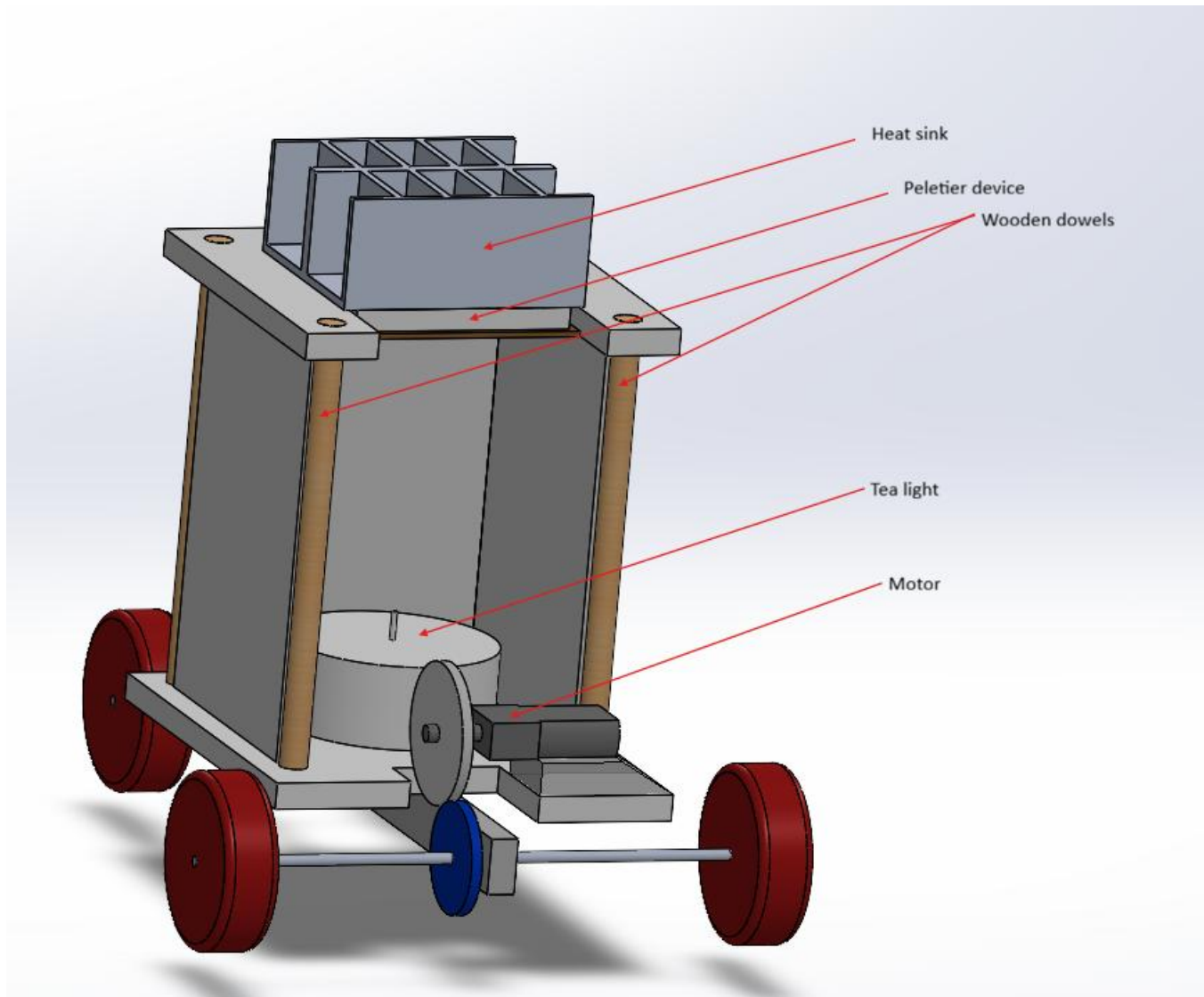


Figure 1 -CAD model of the vehicle with labels

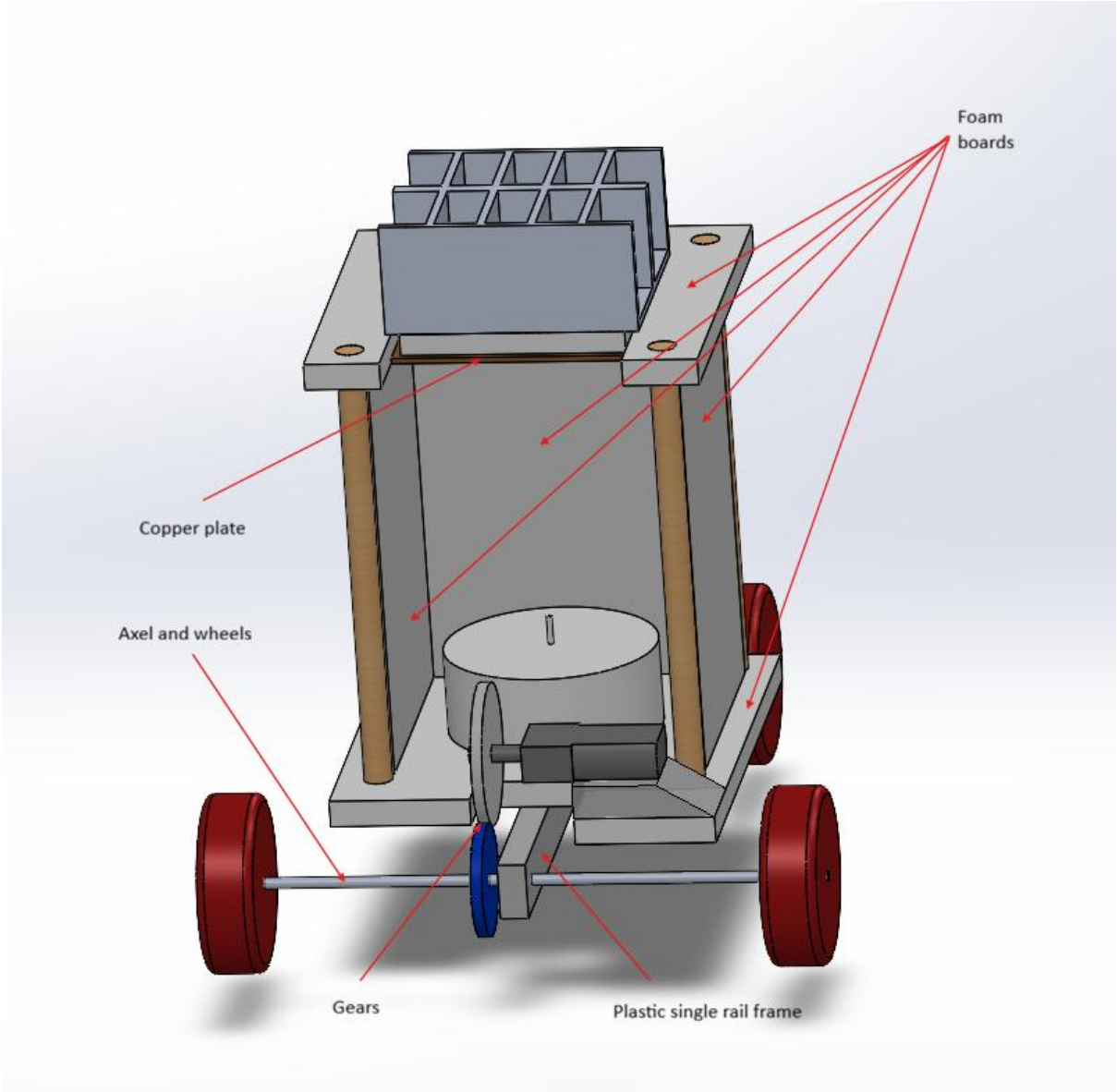


Figure 2-CAD model of the vehicle with labels

For further details, here is a comprehensive list of all the materials that compose the vehicle:

- Wooden dowels of 5mm in diameter
- Tea light candle
- Foam boards of 3/16" thickness
- DC Motor from Abra; model GA12-N20- 3V30 [3]
- Peletier device model TEC1-12706 [4]
- Handmade aluminum heat sink
- Arctic MX4 Thermal paste
- Copper plate
- Thermal paste
- Pair of plastic gears with same number of teeth
- 2 sets of axels with 2 wheels each
- Plastic single rail frame
- Aluminum foil

Because the Peletier device wasn't expected to provide an immense voltage difference, it was safer to choose the lightest possible materials that were available. From kinematics, it is known that if something is heavier, it has more mass which creates a higher inertia which then makes the body more resistant to displacement. In order to keep the overall weight to a minimum, foam boards and light wooden dowels were chosen for the body structure. Furthermore, the heat sink material was chosen to be aluminum due to its light weight (in comparison to copper) and good thermal conductivity. The rest of the car parts didn't have much flexibility in terms of material choices, so they aren't particularly light. There were several proposed motors in the project guidelines, and the team hesitated between two models: the GA12-N20-3V30 from Abra and the 3777 gearmotor from Adafruit Industries. However, The GA12-N20 motor is better because it requires less power and provides usable torque at low speeds, making it more suitable for the low voltage output of a Peltier device. It reduces geartrain complexity because of its significantly lower RPM (30 vs 200). It was also lighter at 10g compared to the 3777 weighing 30.6g.[3][4]

Furthermore, another material property that was important to keep in mind was the thermal conductivity of the parts. For the body, it was important to choose a material that was a poor thermal conductor and a good insulator because in this way, the heat provided by the tea light wasn't absorbed by something else that wasn't the Peletier device or heat sink. For example, if the body was made of copper, which is a good thermal conductor, an important part of the heat provided from the tea light would be absorbed by the structure, and less would go to the Peletier device meaning that the temperature difference would be lower, causing the Peletier to provide smaller voltage difference to the motor. This is therefore, another reason why foam and wooden dowels were chosen for the body because of their bad thermal conductivity. Another part whose role relied on a good thermal conductivity is the heat sink. Heat sinks are generally used to absorb or dissipate unwanted heat to the exterior, and in this case, it dissipates the heat from the Peletier device to the surrounding air to keep the cold side of the device cool. The other materials that were used to protect the device were aluminum foil and thermal paste which are both good conductors and were efficient at transferring the maximum heat through the device and through the heat sink.

2.2 Physical Prototype

Following the SolidWorks assembly, the physical prototype was constructed to the dimensions specified in the CAD. Figures x, x show the complete vehicle.

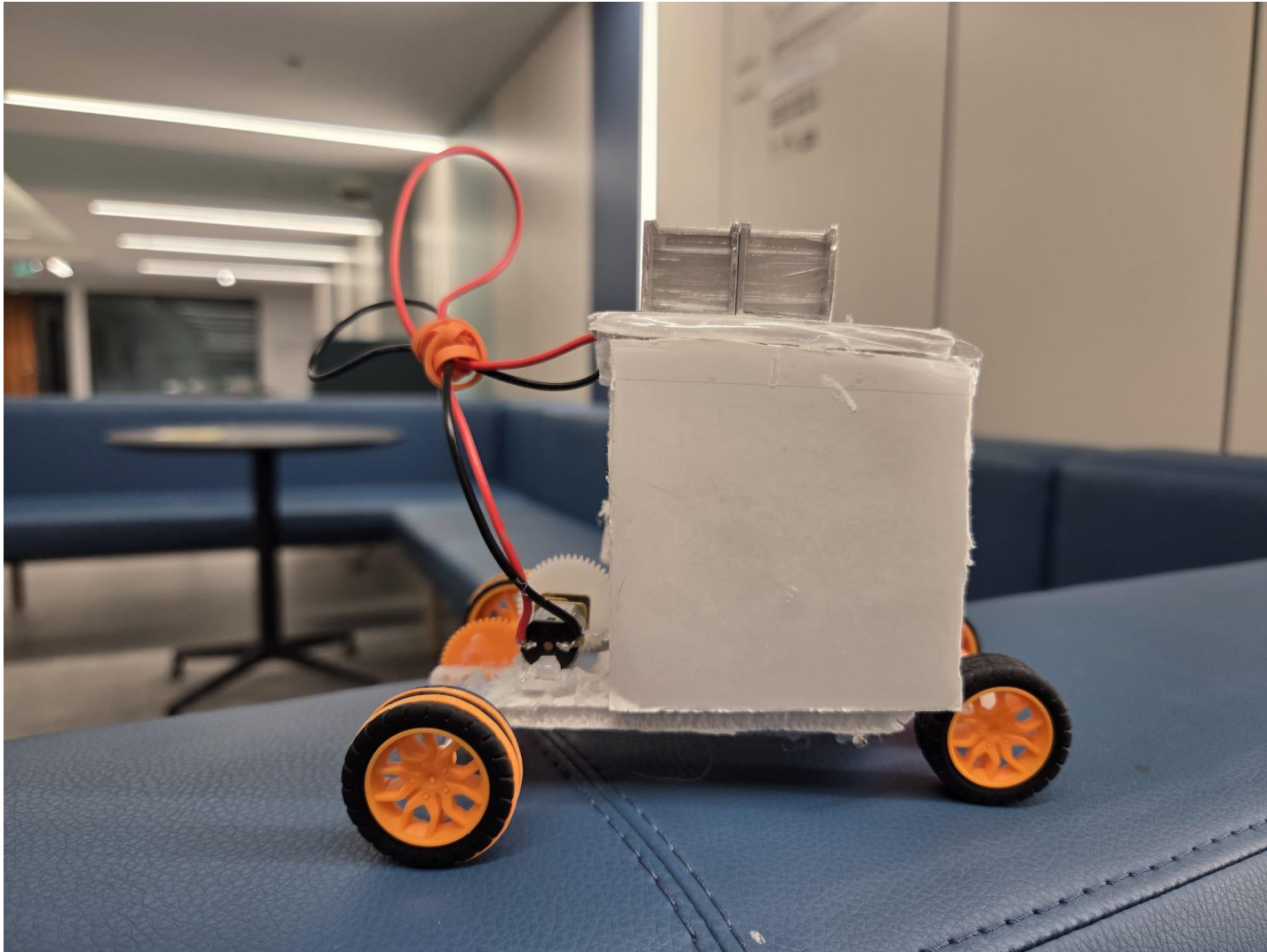


Figure 3-Side View of our vehicle

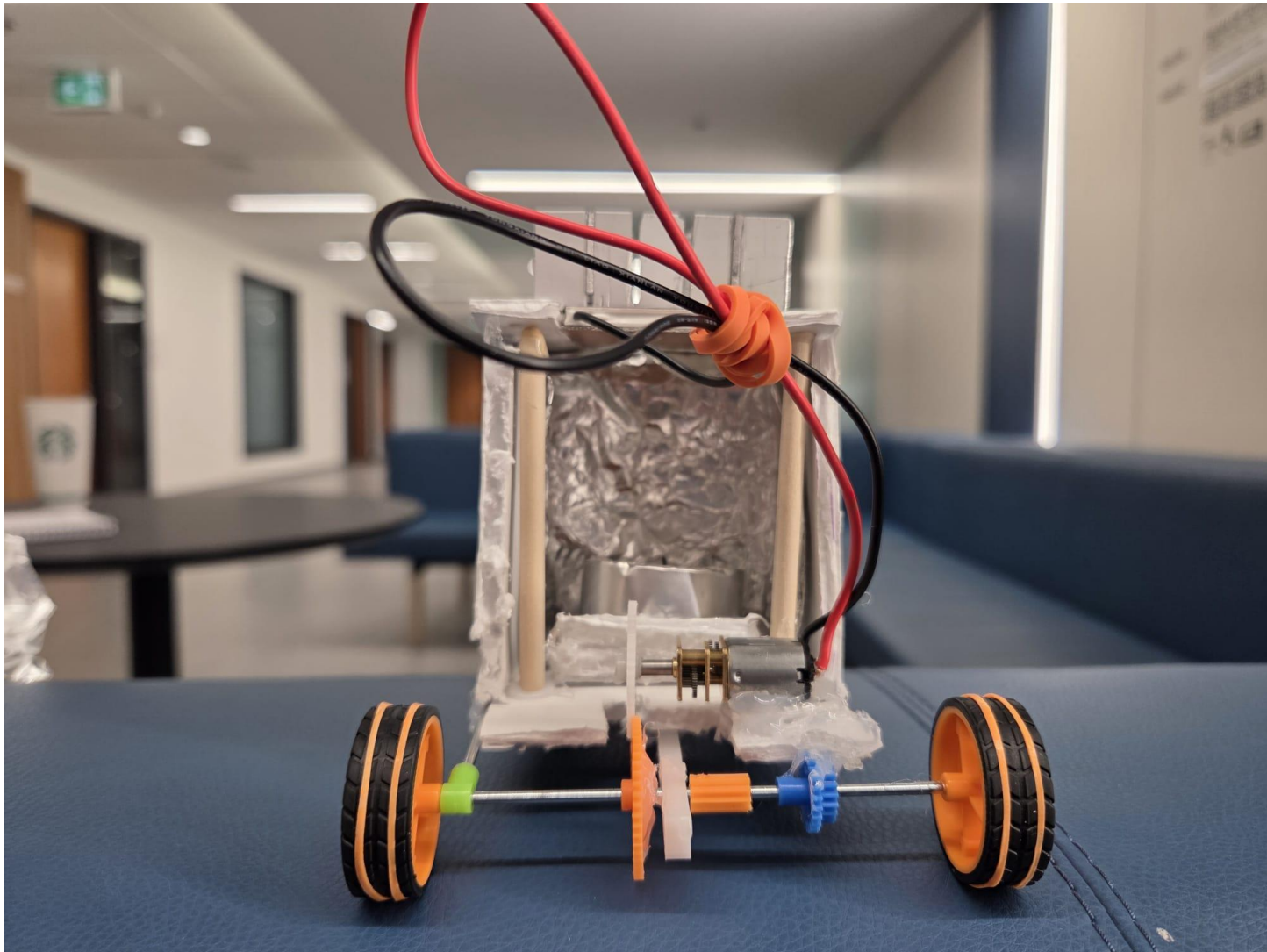


Figure 4-Back View of our vehicle

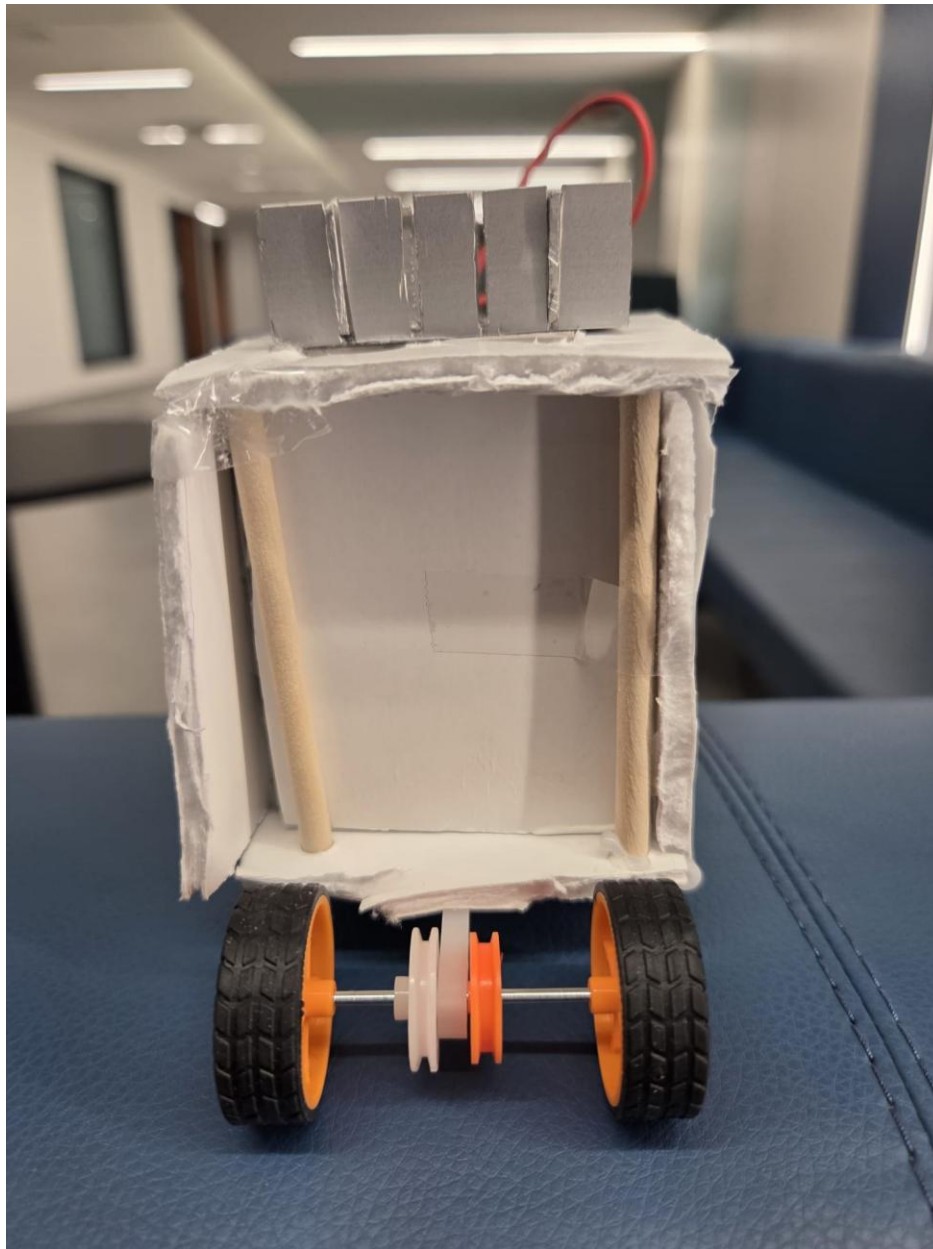


Figure 5-Front view of our vehicle

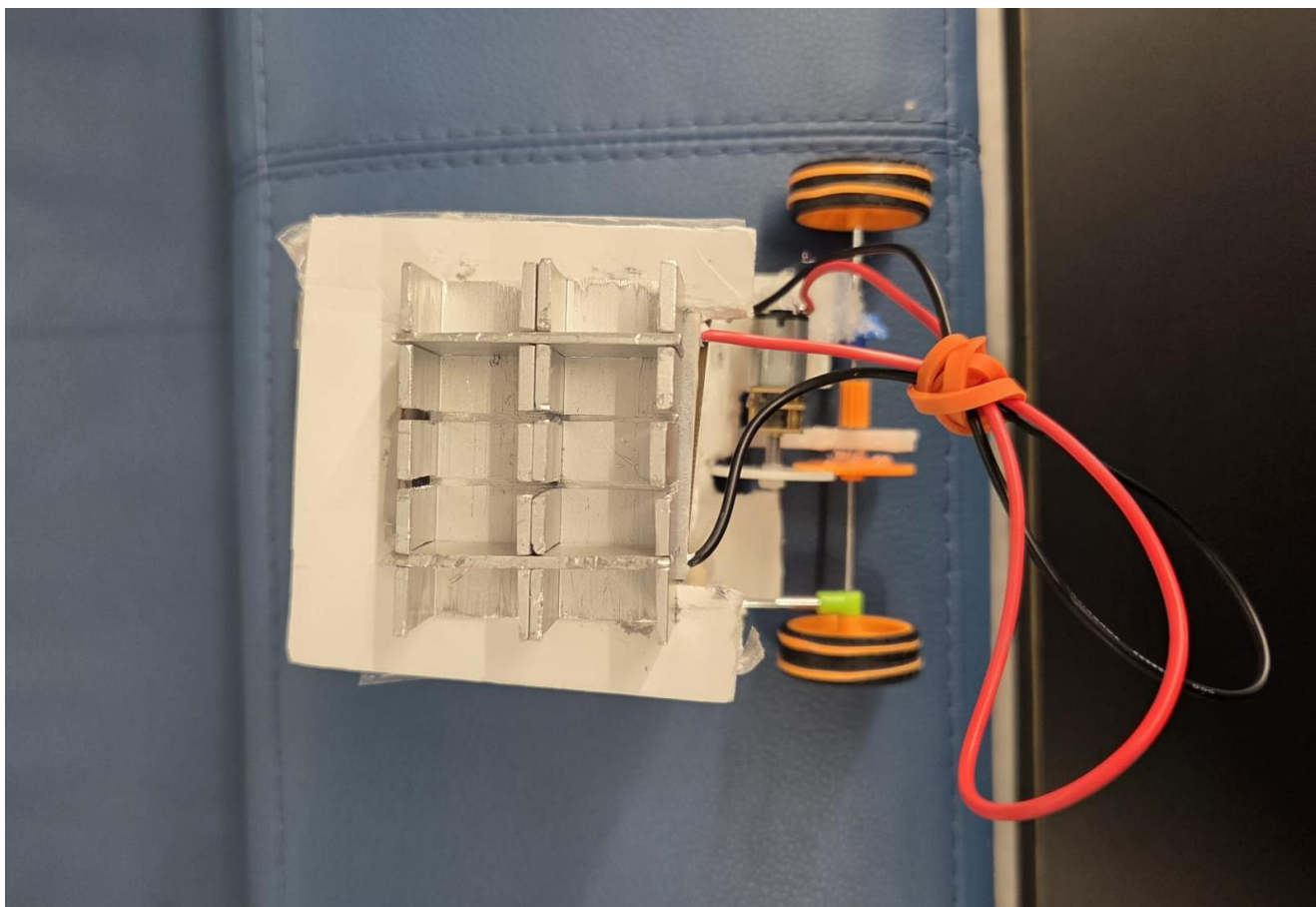


Figure 6-Top View of Our Vehicle

3. Methodology

3.1 Performance Testing of TEC1-12706

The purpose of this test was to analyse the behaviour of the Peltier device when electrical power was supplied. The device was connected to two different batteries: 1.5V and 3V. For each case, the temperature of the hot side and the cold side were recorded over time with a non-contact thermometer. The readings were taken every 10 seconds up until 150 seconds to allow an observable thermal steady state.

3.2 Voltage Generation Test

The purpose of this test was to observe how much voltage the Peltier device generates in different conditions. This test was done once the car was already assembled. One side of the Peltier was exposed to the heat of a tea candle, and the cold side was attached to a heatsink. The two conditions tested were: heatsink only and heatsink with ice. The voltage generated by the modules was measured over time using a voltmeter. The readings were taken every 10s until 2 minutes were reached.

3.3 Vehicle Motion Test

The purpose of this test is to analyse how much of the electrical energy converts into mechanical energy. To measure the displacements of the vehicle, distance markings were placed at intervals of 20 cm up to 150cm. The time of the vehicle took to reach each marked position was recorded. This experiment was repeated for the two conditions: heatsink only and heatsink with ice.

4. Experimental Results

4.1 Temperature over Time of the Peltier

time (s)	1.5V			3V		
	Temperature of the hot side (°C)	Temperature of the cold side (°C)	ΔT	Temperature of the hot side (°C)	Temperature of the cold side (°C)	ΔT
0	26.5		0.00	26.5		0.00
10	30.90	21.10	9.80	35.50	17.20	18.30
20	31.00	21.10	9.90	38.30	17.80	20.50
30	31.20	21.00	10.20	39.50	18.00	21.50
40	31.40	21.00	10.40	40.30	18.70	21.60
50	31.50	21.20	10.30	41.40	19.40	22.00
60	31.50	21.50	10.00	42.50	20.50	22.00
70	31.60	21.90	9.70	42.70	21.30	21.40
80	31.60	21.90	9.70	42.60	22.30	20.30
90	31.40	21.70	9.70	43.90	22.90	21.00
100	31.80	21.90	9.90	44.90	23.60	21.30
110	31.60	21.90	9.70	45.30	24.10	21.20
120	31.90	21.90	10.00	45.50	25.00	20.50
130	32.00	22.50	9.50	45.00	25.50	19.50
140	32.20	22.10	10.10	46.30	26.10	20.20
150	32.10	22.10	10.00	45.60	28.80	16.80

Table 1-Peltier response to with a 1.5V and a 3V volage input

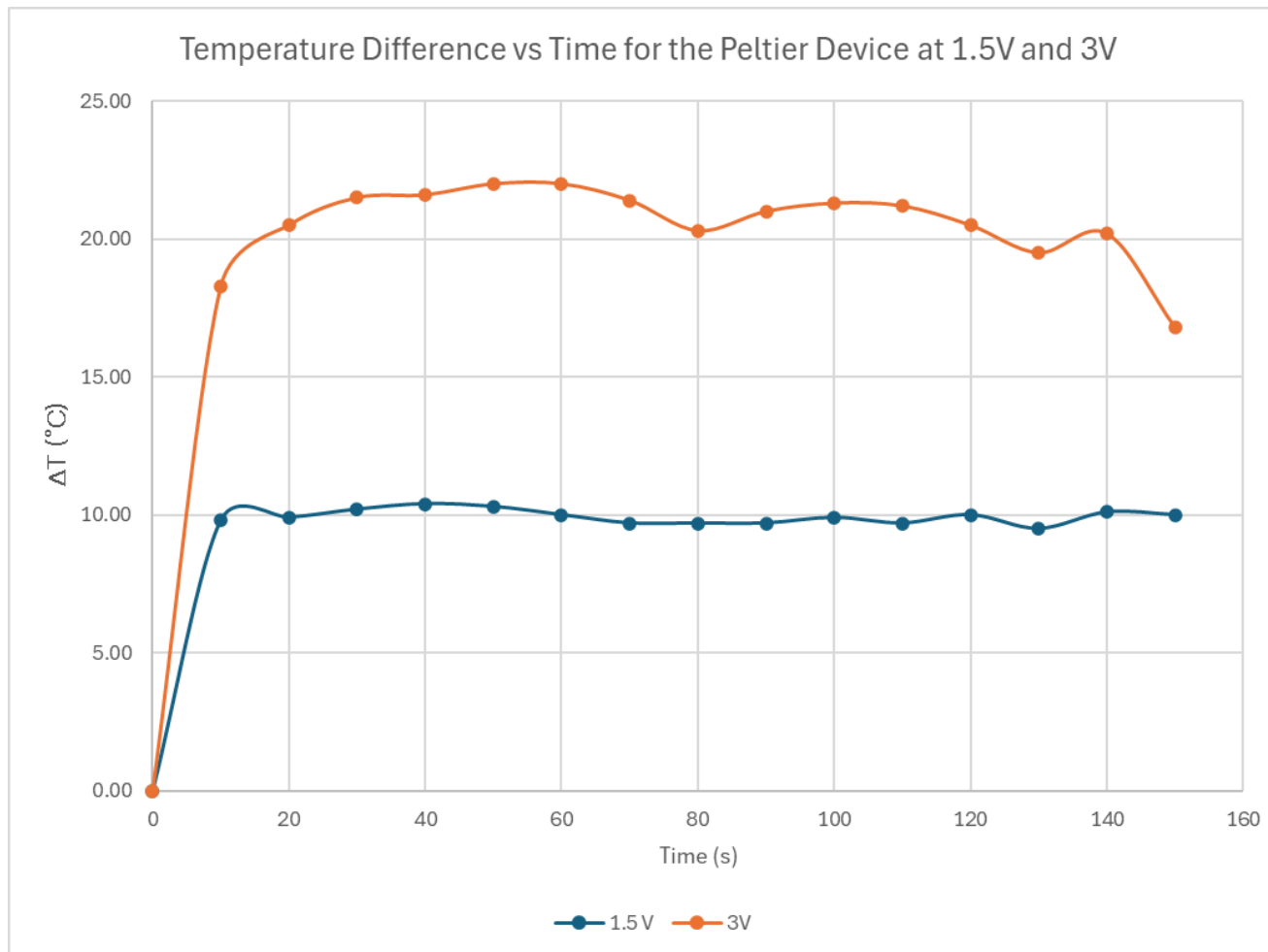


Figure 7-Temperature Difference (ΔT) vs Time for the Peltier Device at 1.5V and 3V

The Peltier module was tested independently to observe its behaviour before integrating it into the car. During the 1.5V test, the temperature difference between was steady from the first 10 seconds, ranging from 9.80V to 10.40V shown in the table below. For the 3V test, the temperature stabilized after 30 seconds.

It is also observed that cold side decreases in temperature in the beginning, as expected. However, after some time, the cold side began to increase in temperature. This means that the heat transfer went over the cooling capacity of the Peltier, making the cold side heat up. Therefore, an effective cooling method, like a heatsink, is necessary to dissipate the heat from the cold side. This would also allow a larger temperature difference, which is essential to improve performance.

4.2 Voltage over Time

Time (s)	Voltage (V)	
	Heatsink	Heatsink with Ice
0	0.00	0.00
10	0.75	0.84
20	0.78	0.88
30	0.84	1.00
40	0.95	1.14
50	0.96	1.20
60	1.03	1.22
70	1.05	1.26
80	1.04	1.33
90	1.04	1.34
100	1.00	1.28
110	0.96	1.30
120	1.00	1.31

Table 2-Measured Voltage Output of the Peltier Over Time under Two Colling conditions (Heatsink and Heatsink with Ice)

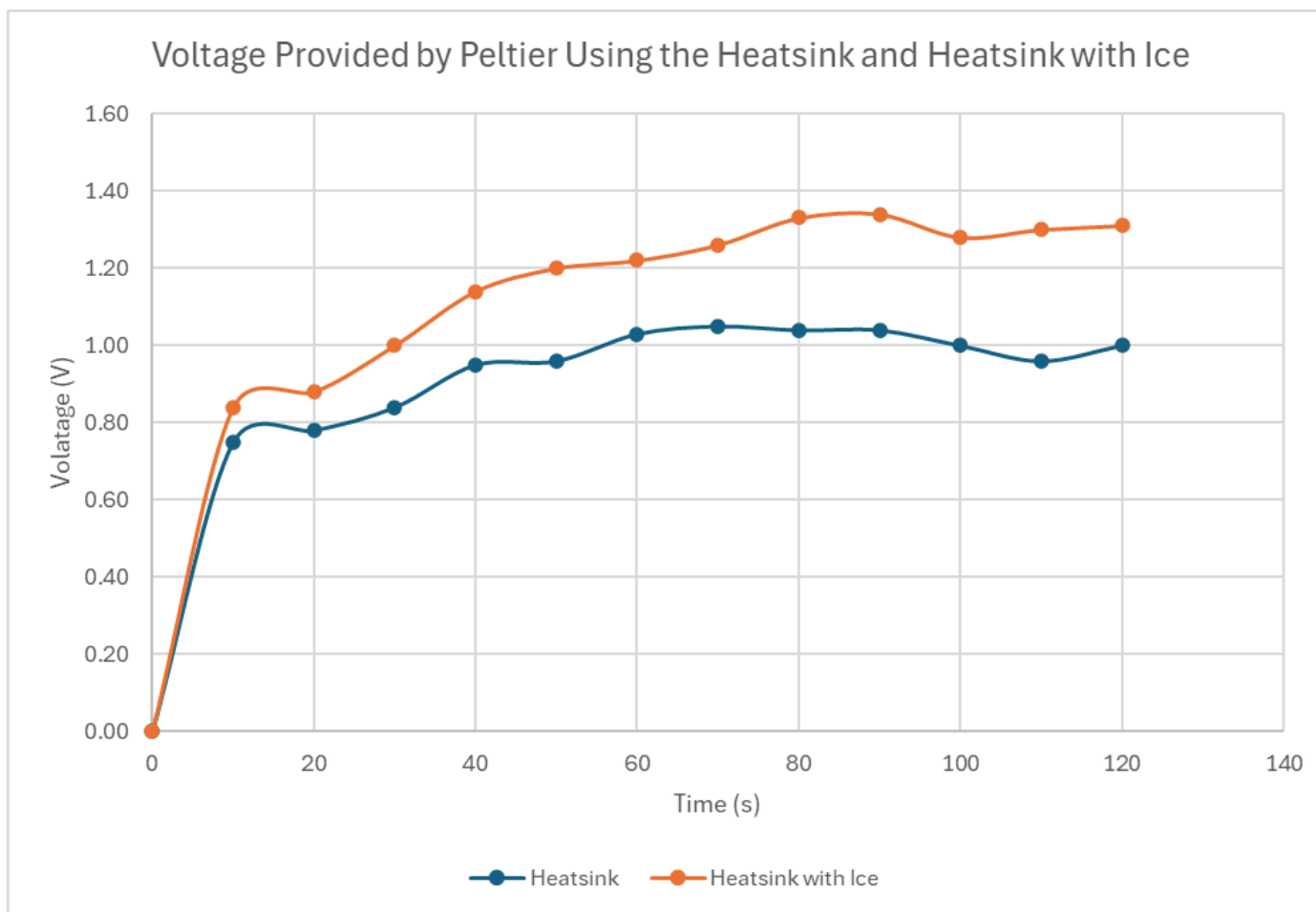


Figure 8-Output Voltage Over Time for the Peltier Device under Different Cooling Conditions

The results show that the output voltage of the Peltier device increases fast at the beginning for both cooling conditions. Then, after around 40 seconds, the voltage stabilizes approximately at 1V for the heatsink only and at around 1.30V for the heatsink with ice. This difference is due to the larger temperature difference across the Peltier when ice is used. Since the voltage generated is directly related to the temperature difference, improving cooling on the cold side increases voltage output. Additionally, both curves show plateau after around 40 seconds, meaning the system reached a thermal steady state.

4.3 Position over Time

Position (cm)	Time (minutes)	
	Heatsink	Heatsink with Ice
0	0.00	0.00
0	0.24	0.07
20	0.44	0.27
40	1.00	0.41
60	1.15	0.55
80	1.30	1.07
100	1.47	1.21
120	2.03	1.34
140	2.21	1.48
160	2.38	2.01

Table 3-Time Required to Reach Different Positions for the Peltier Car under Heatsink and Heatsink with Ice conditions

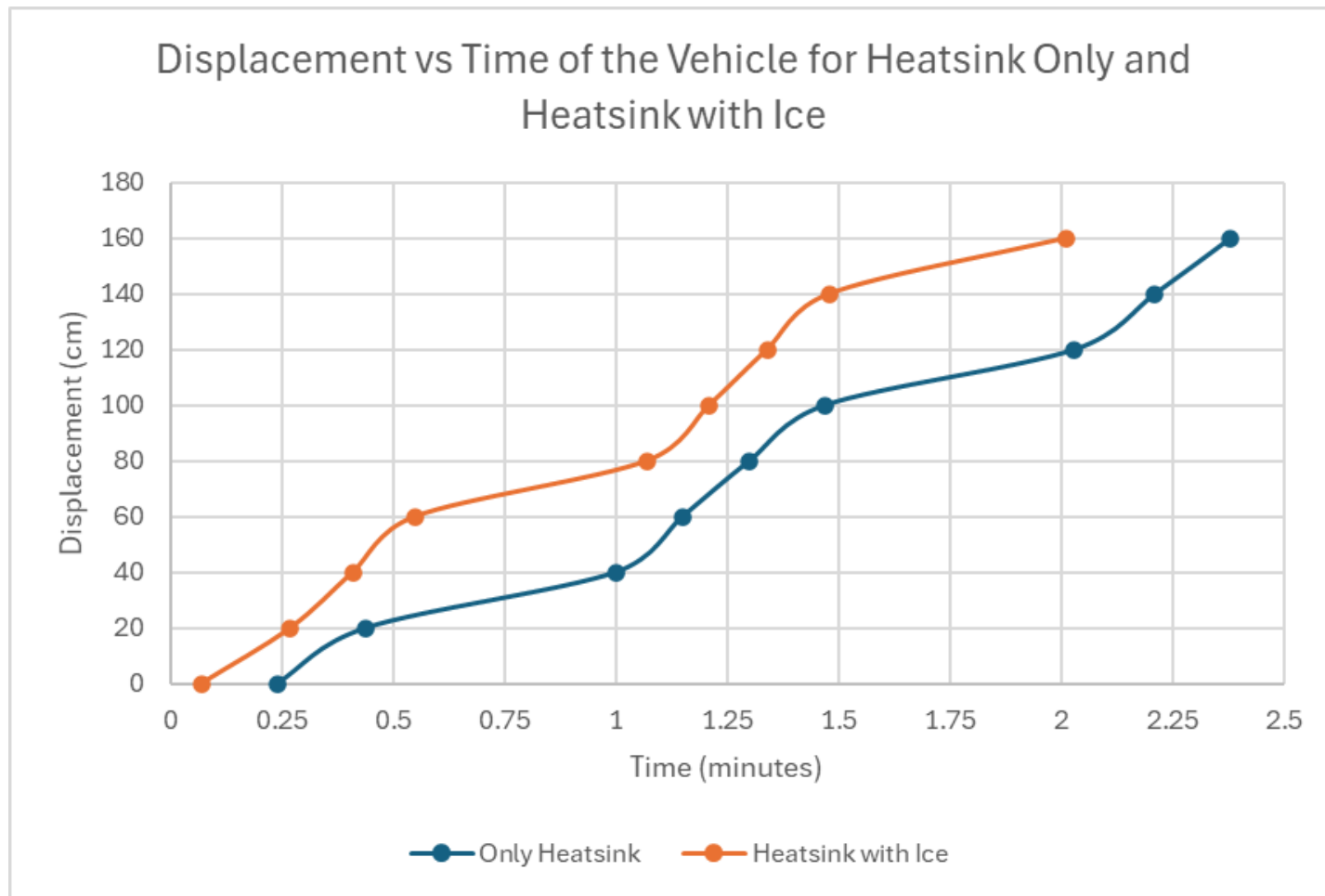


Figure 9-Displacement over Time comparison of the Peltier Car under Different Cooling Conditions

The results show the vehicle reaches each position faster when the heatsink is cooled with ice compared to using the heatsink alone. To reach 100cm, the car takes 1.47minutes with only a heatsink, whereas it takes the car 1.21 minutes with the ice on the heatsink. This trend is consistent across all the experiment.

5. Engineering Analysis and Calculations

5.1 Maximum Theoretical Height for Any Vehicle

In order to estimate the absolute maximum height any car can climb, it is assumed that the only object in common is the Peltier. Therefore, the maximum height will be based on the theoretical maximum power that the Peltier module can generate under ideal conditions. According to the manufacturer specifications, the module has a maximum voltage of 14.4V and an internal resistance of 2 Ω . Using the maximum power transfer equation:

$$P_{max} = \frac{V^2}{4R}$$

Therefore, the electrical energy generated is:

$$E = Pt$$

Where t is the time, which will depend on the methods used to heat and cool both side of the Peltier. According to the tea candle's package, on average, can run for 4h.

Assuming that all the electrical energy is converted into mechanical work for any motor, the maximum height the vehicle cab reach is given by the potential energy equation:

$$h_{max} = \frac{E}{mg} = \frac{P_{max} t}{mg}$$

This final equation represents the theoretical maximum height for any car. It will vary depending on the mass (m) and the time (t) it runs.

5.2 Expected Maximum Velocity

An important assumption is that 100% of the electrical energy generated from the Peletier device will directly contribute to the useful mechanical energy produced by the motor. Due to the inefficiencies in the motor, the number will be lower. In addition, while peak power is being used, it may not be able to sustain itself for a long time. The maximum voltage measured, with ice, is 1.38V. The GA12-N20-3V30's datasheet specifies that it will achieve 30 RPM at 3V. Seen as the voltage achieved peaks at 1.38V and assuming that the RPM is directly proportional to the voltage with a cut-off voltage of 1.0V, it is estimated that the RPM achieved will be 14 RPM. The vehicle's 1:1 gear reduction means that the RPM on the driven axle will be 14 RPM. The driven wheels have a diameter of 0.03175m. 14 RPM, when converted to seconds, yields 0.233 revolutions per second. Multiplying the wheels' diameter with the revolutions per second results in the maximum velocity.

$$V_{max} = D * \frac{Rev}{second}$$

$$V_{max} = 0.03175m * 0.233 \frac{Rev}{second}$$

$$V_{max} = 0.0074 m/s$$

This velocity would be achieved during the 1m stretch preceding the incline.

5.3 Expected Maximum Height

The maximum height the vehicle can be expected to reach is determined by the conversion from electrical energy to potential energy. An integral assumption that determines the expected maximum height is that 100% of all electrical energy is converted to useful mechanical energy. This omits mechanical drivetrain losses (friction) and heat loss from a lack of complete insulation. Referring to the position over time graph, it is noted that a time of 72.6 seconds is required to move the vehicle 1m (100cm), and the recorded mass of the vehicle is 78g (0.078kg). The nominal current draw from the GA12-N20-3V30 motor at max efficiency is 0.02A. Knowing that a maximum of 1.38V can be produced by the Peletier device under load using ice and the tealight, the maximum electrical energy can be calculated:

$$\textit{Electrical Energy} = \textit{Potential Energy}$$

$$P_{elec} \times t = mgh_{max}$$

$$1.38V \times 0.02A \times 72.6 s = 0.078kg \times 9.81 \frac{m}{s^2} \times h_{max}$$

$$h_{max} = 2.62m$$

The expected maximum height of 2.62m is higher than the evaluation slope. The total height of the evaluation slope can be measured by taking the sine of the angle with the length of the slope, which is 36in or 0.9144m:

$$h = L \times \sin(\theta)$$

$$h = 0.9144m \times \sin(20)$$

$$h = 0.3127m$$

Although the real final height is determined by both a kinetic and potential energy, since the expected maximum height of the vehicle is significantly higher, it can be hypothesized that the vehicle will be able to reach the top of the slope.

6. Efficiency Analysis

The overall performance of the heat-powered vehicle depends on the efficiency of its various subsystems. Therefore, the total efficiency can be divided into three stages: the heat transfer efficiency from the tealight to the Peltier element, the thermodynamic efficiency of the Peltier element converting thermal energy into electrical energy, and the mechanical efficiency of the DC motor and gear assembly converting electrical energy into the kinetic energy of the vehicle. These different energy conversion stages will be analyzed below.

6.1 Thermodynamic efficiency of vehicle

The overall thermodynamic efficiency ($\eta_{overall}$) measures how effectively the entire vehicle system converts the thermal energy from the candle into useful mechanical motion. It is calculated by dividing the total mechanical work output (W_{out}) by the total heat input (Q_{in}).

$$\eta_{overall} = \frac{W_{out}}{Q_{in}}$$

1. Total Mechanical Work Output

The useful work performed by the vehicle happens in two stages: overcoming rolling friction along the 1-meter flat surface and gaining potential energy while climbing the 20° inclined plane.

$$W_{out} = mgh + W_{friction}$$

Where m is the vehicle's total mass, h is the maximum vertical height reached on the ramp, and $W_{friction}$ is the total energy spent overcoming rolling resistance over the entire distance traveled.

2. Total Heat Input

During the experiment, it is not feasible to accurately calculate the weight of the consumed wax by weighing the tea candle before and after operation. This is due to the physical characteristics of the tea candle: as the paraffin melts, it pools inside the aluminum casing. Consequently, the measured mass of the tea candle after the experiment increased rather than decreased, rendering direct mass measurement unreliable.

To address this issue, we cannot rely on the mass difference before and after the experiment to determine the heat input Q_{in} . Given that the initial mass of an unlit tea candle is known to be 14g, and it has an approximate burn time of 4 hours (14,400 seconds), we can instead calculate Q_{in} by finding the theoretical mass flow rate.

$$\dot{m}_{max} = \frac{m_{total}}{t_{total}} = \frac{14g}{14400s} = \frac{0.00097g}{s}$$

With the mass flow rate determined, the total thermal energy introduced into the system during the vehicle's operation can be calculated using the Lower Heating Value (LHV). The LHV represents the amount of heat released by completely combusting a specified quantity of fuel; for standard paraffin wax, this value is widely accepted as 42 MJ/kg. [5] Therefore, the total heat input equation is:

$$Q_{in} = \dot{m}_{wax} \times t_{run} \times LHV$$

t_{run} is the total recorded run time for the vehicle's motion.

6.2 Mechanical efficiency of system

The mechanical efficiency evaluates how effectively the electrical power supplied by the Peltier module is converted into the actual kinetic and potential energy of the vehicle. This section

isolates the performance of the electromechanical components, specifically the DC motor and the gear transmission system.

The fundamental equation for mechanical efficiency is the ratio of the useful mechanical work output to the electrical energy input:

$$\eta_{mech} = \frac{W_{out}}{E_{elec}}$$

$$E_{elec} = P_{max} \cdot t_{run}$$

It is anticipated that the mechanical efficiency will be significantly lower than 100% due to substantial electromechanical and frictional losses.

6.3 Thermodynamic efficiency of the Peltier

The thermodynamic efficiency of the Peltier module (TEC1-12706) evaluates its ability to function as a Thermoelectric Generator (TEG), converting the thermal energy absorbed at its hot junction into useful electrical power.

1. Actual Thermodynamic Efficiency ($\eta_{Peltier}$)

The actual thermal efficiency is defined as the ratio of electrical energy generated (E_{elec}) to the total heat energy absorbed at the hot side ($Q_{absorbed}$).

$$\eta_{Peltier} = \frac{E_{elec}}{Q_{absorbed}}$$

Because the TEC1-12706 is a commercial module, the manufacturer does not provide exact material properties, such as the Seebeck coefficient (α) and thermal conductance (K). Without these key parameters and specialized sensors to measure heat flux, calculating the actual absorbed heat is unfeasible. Therefore, this analysis evaluates the system's absolute limits using theoretical Carnot efficiency instead.

2. Theoretical Maximum (Carnot Efficiency)

In thermodynamics, the absolute maximum theoretical efficiency any heat engine can achieve is dictated by the Carnot efficiency limit (η_{carnot}). This limit depends entirely on the absolute temperatures of the hot junction (TH) and the cold junction (TC), measured in Kelvin.

$$\eta_{carnot} = 1 - \frac{T_C}{T_H}$$

Application to Experimental Data: Based on the 3V test data recorded in the appendix at $t = 140$ s, the hot side reached 46.30°C (319.45 K) and the cold side was 26.10°C (299.25 K).

Substituting these absolute temperatures yields:

$$\eta_{carnot} = 1 - \frac{299.25\text{K}}{319.45\text{K}} = 6.32\%$$

This indicates that under these specific temperature conditions, the maximum theoretical efficiency of the module is only **6.32%**.

7. Discussion

7.1 Comparison Between Expected and Actual Results

The theoretical models in Section 5 calculated maximum heights and speeds based on a frictionless, ideal system. The calculated maximum reachable height was 2.62m. In reality, the tested ramp only went up to 0.313m but effectively confirms that the maximum reachable height was sufficient.

However, the final vehicle design was a functional success. It completed the flat surface run and climbed the 20° incline. We only achieved this after making a major design change. Initially, the car stalled on the ramp because our gear setup (a large gear driving a small axle gear), overdriving the driven axle and lacked torque. We fixed this by swapping the gears to a 1:1 gear reduction setup. This resulted in a maximum velocity of 0.0256 m/s, which is significantly higher than the theoretical maximum velocity of 0.0074 m/s. It is uncertain why the velocity differs by a large margin, but can be attributed to a difference in the net RPM of the motor under minimum operating voltage. Instead of the hypothetical 14 RPM, it could have reached or exceeded its advertised maximum 30 RPM.

In mechanical systems, power is the product of speed and torque. Since the motor provides a fixed amount of power, reducing the rotational speed of the wheels through this new gear ratio acts as a multiplier for torque. Trading top speed for this massive increase in rotational force is

what finally allowed the vehicle to overcome gravity. The remaining gap between our theoretical numbers and actual performance is explained by the low Carnot efficiency limit (6.32%) and normal mechanical friction.

7.2 Effect of Different types of cooling

Our test data shows a clear link between cold-side cooling and how fast the car moves. Based on the Seebeck effect, the voltage from the Peltier module relies directly on the temperature difference (ΔT). We saw this happen in our flat-surface tests. With just the aluminum heatsink and room temperature air, the car took 2.38 minutes to travel 160 cm. When we added ice to the heatsink, it kept the cold side from heating up. Because of this, the car finished the same 160 cm track in just 2.01 minutes, showing a 15.5% improvement in speed. Presumably, a larger amount of ice, with the addition of salt, would aid in slowing down the melting of the ice cubes. This would allow for increased voltage for a longer period of time, but would add additional mass. It was not necessary for this project because the allotted time (15 minutes) was sufficient for the vehicle to complete the 1m stretch and the incline.

7.3 Sources of Error

Even though the final car worked, several factors caused efficiency losses in our system:

Heat Loss: The tea candle is an open flame. Even with the foam walls, a lot of the heat escaped into the surrounding air instead of going into the Peltier module's hot side as the rear side is open (to put in the tea light)

Mechanical Friction: We used a plastic gear train and plastic axles rubbing directly against the frame. Without metal ball bearings, this sliding friction constantly slowed the car down.

Misalignment of the axles and the wheels also causes mechanical losses, which can be resolved with having higher quality wheels and axles. The presence of warp between the front and rear axles causes the vehicle to slightly skew to one side.

Measurement Limits: As mentioned in Section 6.1, the melted wax pooled inside the candle cup. This made it impossible to get an accurate weight of the burned wax on a standard scale, meaning we had to use a theoretical average to calculate our heat input.

7.4 Improvements

To make the car run even better in the future, we could make a few practical changes:

- **Ball Bearings:** Adding small metal ball bearings to the wheel axles would cut down on the sliding friction and let more motor power go directly to the wheels.
- **Stronger Insulation:** Line the heating chamber with fiberglass or ceramic tape. This would trap more heat from the flame and direct it straight to the copper plate.
- **Two axle rails:** Using two rails would allow for much more stability and would always keep both axles perfectly parallel. This would help improve the gear alignment, which is crucial to the proper functioning of the vehicle.
- **Larger wheels:** Larger wheels would increase the distance traveled per motor rotation, improving speed and efficiency, which is beneficial for a low-power thermoelectric vehicle. It would also help the vehicle travel up the ridge between the flat surface and the incline surface. However, this can only be done if the motor can still supply enough torque to move the vehicle.
- **Stiffer chassis:** A portion of the energy is lost in the deformation of a flexible chassis like the one in the vehicle. Having a stiffer one would create less energy losses and this energy will be used to create the forward motion of the vehicle. Metal rods were required to support the motor, needlessly increasing weight.
- **Lower center of gravity:** A lower center of gravity improves stability and maintains consistent wheel contact with the ground. Four wheels on the surface allows for more grip, and having one of the rotating ones not in contact would harm the efficiency.

8. Conclusion

This project successfully applied thermodynamic principles to a practical engineering design. It was demonstrated that the thermal energy from a single tea candle, combined with an aluminum heatsink, can generate sufficient electrical power to drive a vehicle across a flat surface and up a 20° incline without the need for significant gear reduction beyond the motor's output.

The most notable observation during testing was the direct impact of the temperature differential (ΔT) on system performance. The application of ice to the heatsink effectively maintained a lower cold-side temperature, which noticeably increased the vehicle's speed.

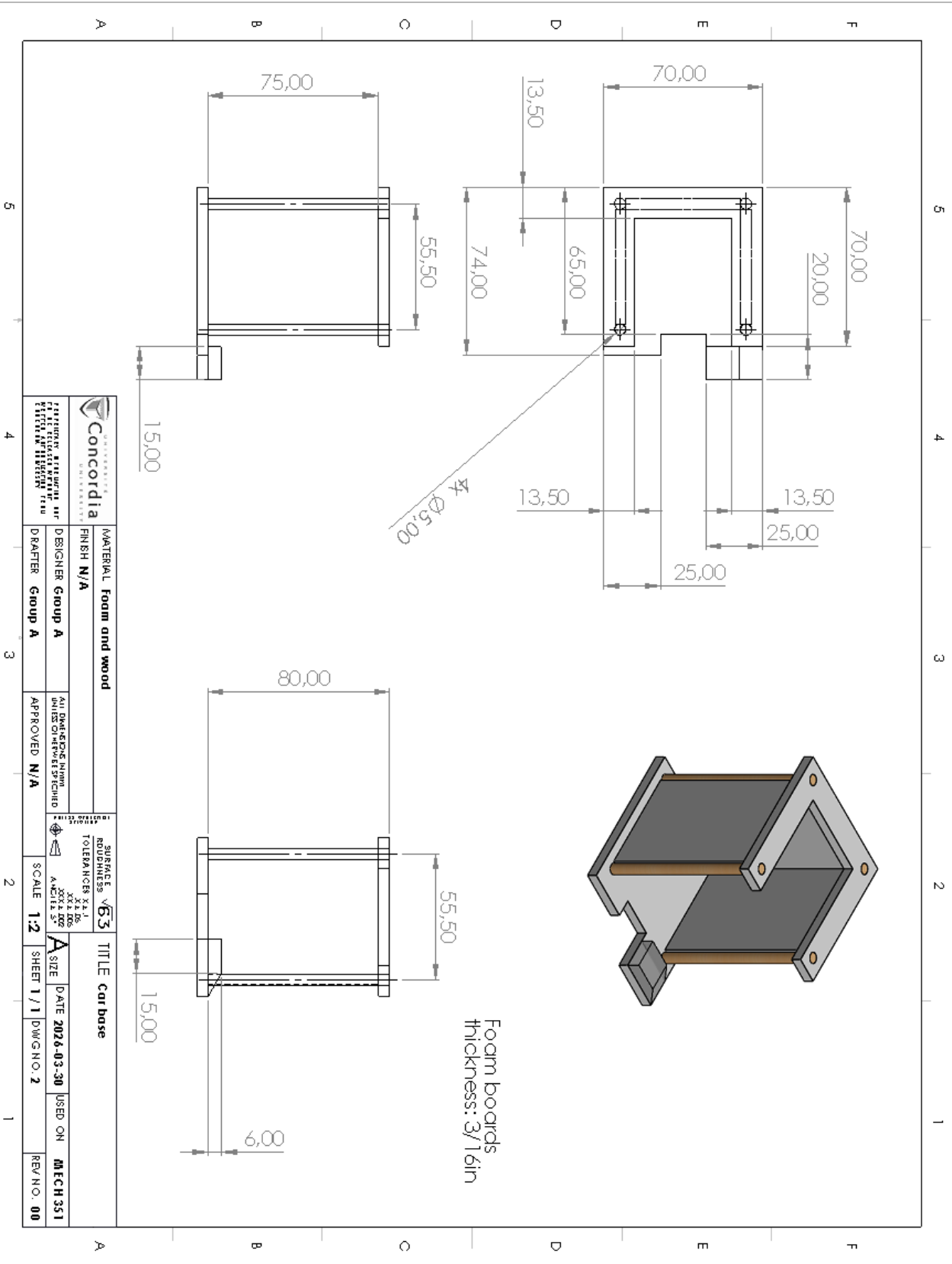
Furthermore, the initial failure on the ramp provided a critical engineering insight: electrical power generation must be matched with an appropriate mechanical transmission system. The initial gear configuration was optimized for speed on flat ground, causing the motor to stall under the gravitational load of the incline. By identifying this design flaw and switching to a gear reduction setup, the fundamental mechanical principle of sacrificing rotational speed to multiply torque was successfully applied. Even with a maximum theoretical Carnot efficiency of just 6.32%, a functional vehicle was built by effectively balancing thermal power generation and mechanical transmission.

9. References

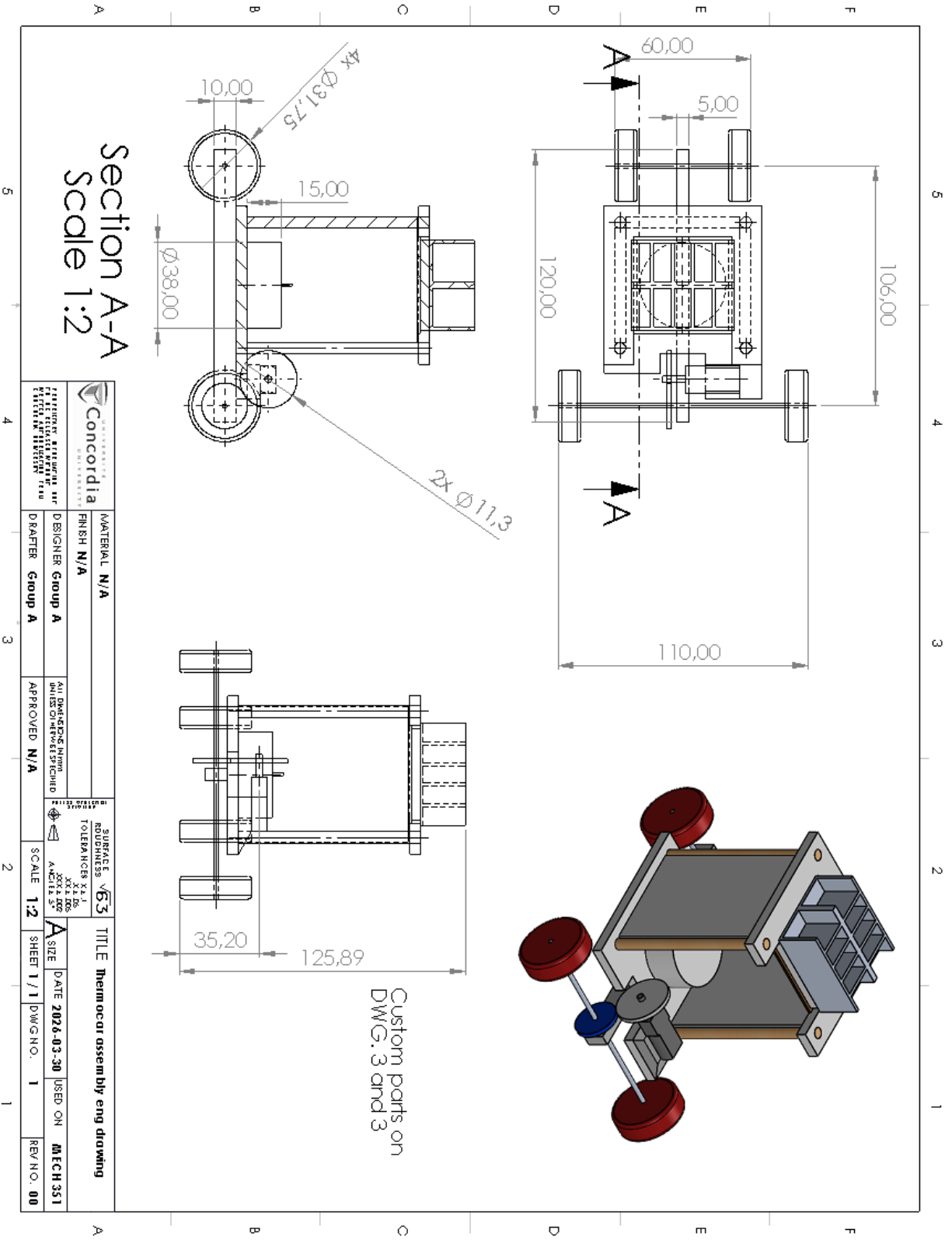
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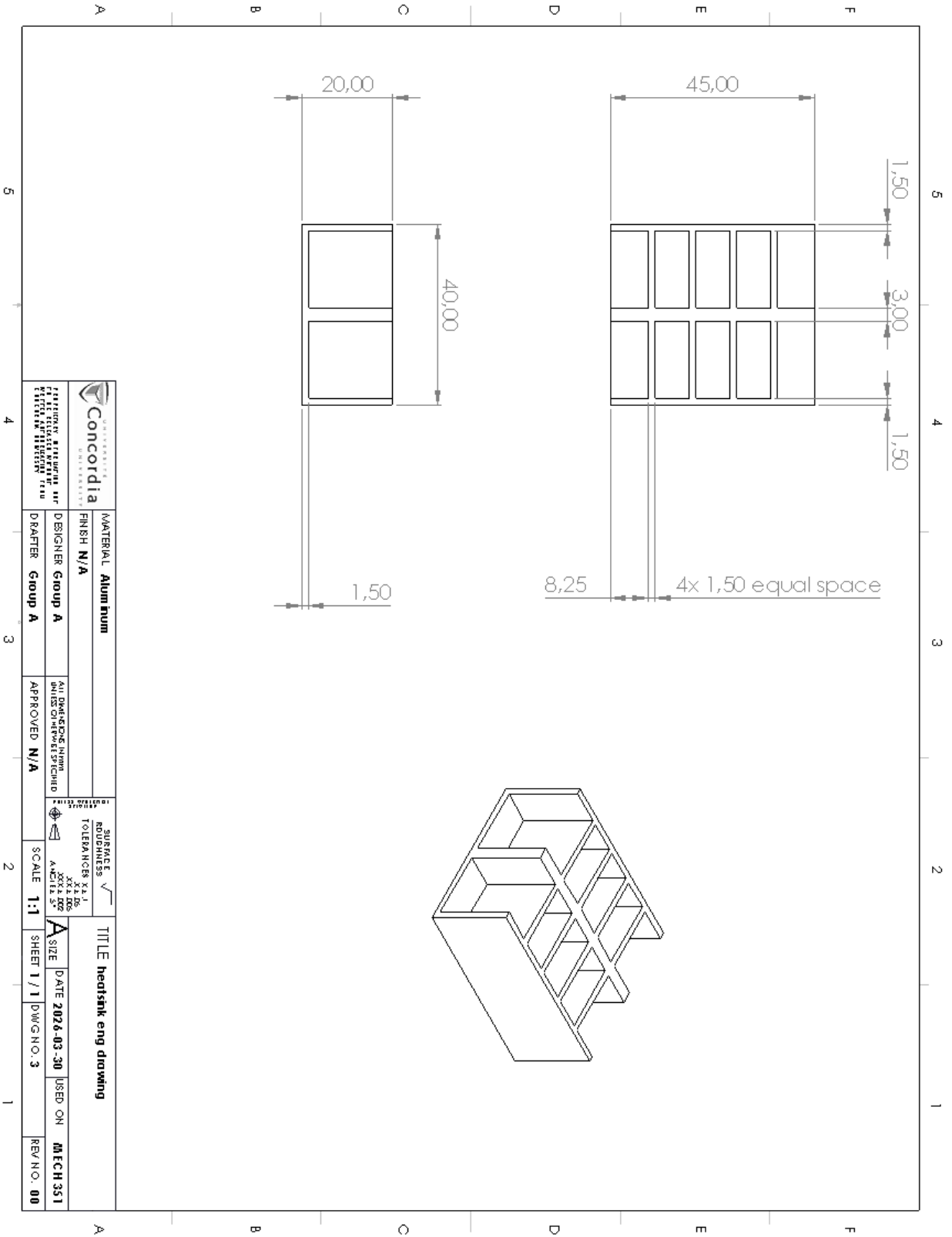
10. Appendices

Here are the engineering drawings of the vehicle assembly and the custom parts



<p>UNIVERSITY OF Concordia UNIVERSITY</p> <p>ENGINEERING, ARCHITECTURE, DESIGN MECHANICAL ENGINEERING FACULTY OF ENGINEERING</p>		<p>MATERIAL Foam and wood</p>		<p>SURFACE FINISH ✓63</p> <p>TOLERANCES XX ± 0,20</p> <p>SCALE 1:2</p>		<p>TITLE Car base</p>	
<p>DESIGNER Group A</p>		<p>APPROVED N/A</p>		<p>DATE 2026-03-30</p>		<p>USED ON MECH 351</p>	
<p>DRAFTER Group A</p>		<p>SCALE 1:2</p>		<p>SHEET 1 / 1</p>		<p>DWG. NO. 2</p>	
<p>REV. NO. 00</p>		<p>REV. NO. 00</p>		<p>REV. NO. 00</p>		<p>REV. NO. 00</p>	





<p>Concordia UNIVERSITY</p>		<p>MATERIAL Aluminum</p>		<p>TITLE headstank eng drawing</p>													
<p>FINISH N/A</p>		<p>DESIGNER Group A</p>		<p>DATE 2026-03-30</p>													
<p>D/RAFTER Group A</p>		<p>APPROVED N/A</p>		<p>USED ON MECH 351</p>													
<p>SCALE 1:1</p>		<p>SHEET 1 / 1</p>		<p>DWG/NO. 3</p>													
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