School of Engineering EGR Mercer University

TO: Dr. Joanna Thomas

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RE: EGR 107 - 003

DATE : March 21, 2018

1. Introduction

1.1 Purpose and the Objective of the Project

The K'nex Car design is the final project given in the freshman engineering design class at the Mercer University School of Engineering. For this assignment, each team is assigned by our instructor. The purpose of the project is to introduce fundamental engineering concepts to the students by giving them the opportunity to work with a client, just as in a professional situation. The objective of the assignment is to build a K'nex car that meets the required project specifications and perform optimally in the competition assigned by our client, the Hill Climber event. In this event, our vehicle must travel in multiple heats across a track at different levels of inclination.

1.2 Rules for our Competition

Our client, Dr. Laura Moody, assigned us the Hill Climber event. The Hill Climber consists of multiple rounds in which the cars must travel up a hill at a specific inclination. With each progressive round, the hill's angle will increase. To win the hill climber event, our team's car must be the first to reach the top of the hill in the final round while following all the rules of the event. The final product must be constructed only from the components in our

parts kit. The teams cannot use glue for construction. Teams may not disassemble or modify the mousetrap, DC motor, and the spring motor in our parts kit. Each attempt must commence within 60 seconds being called. All parts of the K'nex Car must travel with the vehicle when climbing. All K'nex Cars must start themselves; no other aids are allowed.

1.3 Timeline and Due Dates

Date	*What's due?*
March 21	K'nex Proposal
March 28	K'nex Car PDR and Presentation
April 4	K'nex written Test Plan
April 6	Competition Day - Engineering Expo
April 18	K'nex Car CDR and Presentation

2. Feasibility Criteria

The feasibility criteria were selected based on the project specifications provided by our client, Dr. Moody. The designs must pass these feasibility criteria to be considered for production.

- The vehicle must only be composed of K'nex parts.
- Dimension constraints for the K'nex Car:
    - Cannot be longer than 12"
    - Cannot be higher than 18"
    - Cannot be wider than the width of one lane
- The vehicle does not rely on rubber bands to produce its motion.
- The vehicle must not exceed the lane width.

3. Merit Criteria

3.1 Vehicle Mass

We chose mass as a merit criterion for our K'nex Car because it impacts velocity. Ideally, the car's frame should be lighter so the motor would not be constrained. Additionally, mass proves a critical factor for this event since the vehicle will have to do more work (W = F*d) against gravity with each round. For this reason, we made this merit criterion worth 40%. The minimum mass for the vehicle to receive a merit score is 500 g, and the maximum mass is
1300 g.

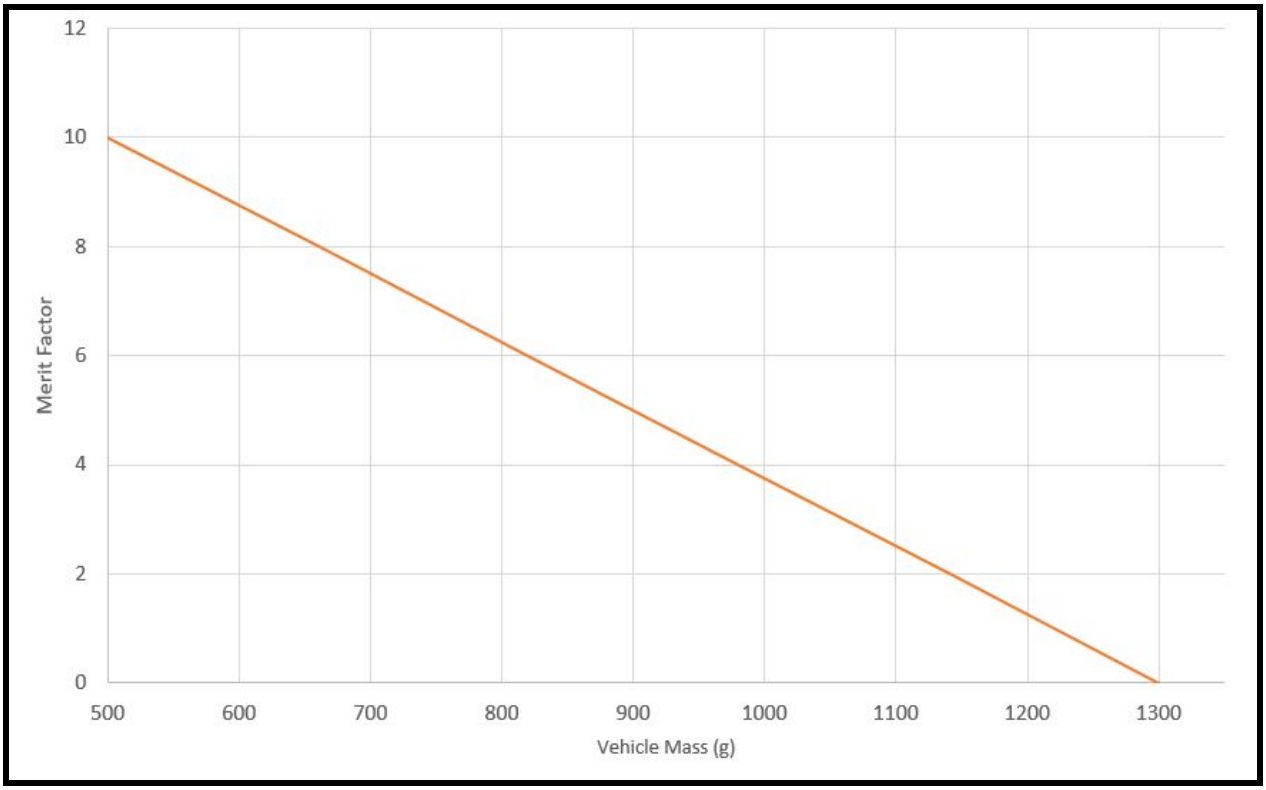

Figure 1: Merit Curve for Vehicle Mass

3.2 Velocity

We chose velocity as a merit criterion for this project since velocity would contribute to the result of the hill climber competition. Since each K'nex car will only have 90 seconds to climb the hill, velocity is a quality that will ensure the vehicle can travel the necessary distance within the maximum of 90 seconds. Furthermore, the team with the fastest car in the

last round (hill with the largest incline) will be the winner of the Hill Climber. The weight of this merit criteria is 20% because it will ensure the K'nex car competes in the entirety of the event, and may even be the deciding factor in winning the competition.

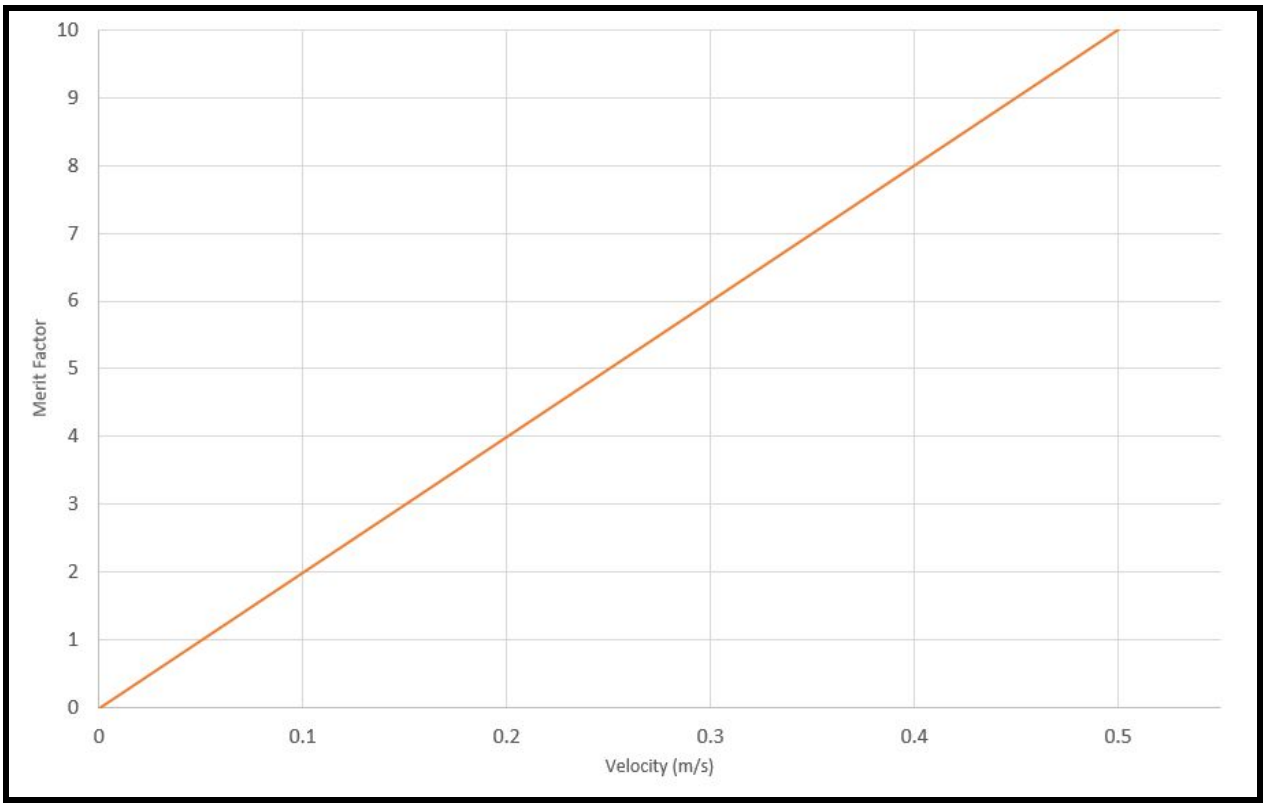

Figure 2: Merit Curve for Velocity

3.3 Torque

We chose torque as a merit criterion for this project since torque will determine the amount of gravitational force incline the car can counteract. This characteristic greatly depends upon where and how weight is distributed throughout the vehicle, the type of motor used, and the gear ratio. Greater torque will help our K'nex car to complete the later stages of the competition as the hill becomes steeper. The merit weight for this criteria is 40% not only for its value to the car's performance but also because it accounts for the car's overall design.

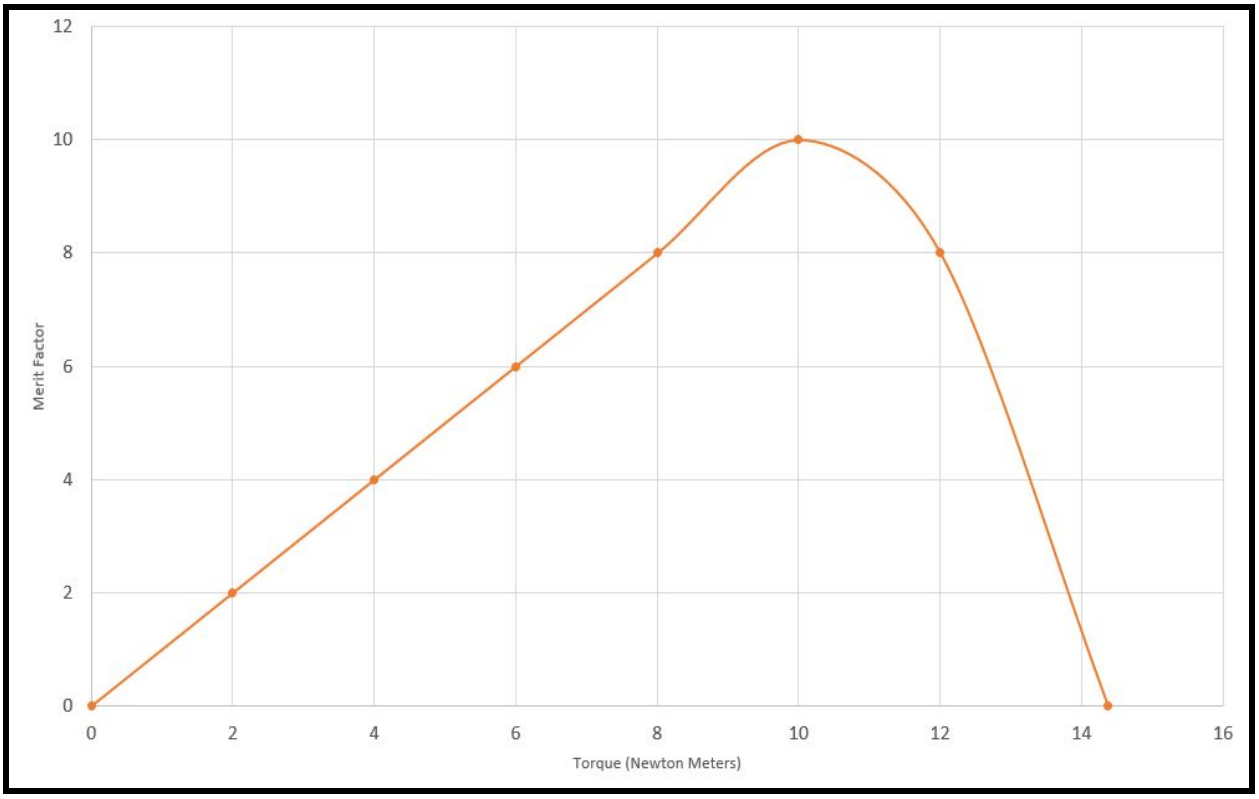

Figure 3: Merit Curve for Torque

4. Preliminary Design Concepts

4.1 Design 1

Design 1 will be a two-wheel drive K'nex car; the design will have a 5.715 cm diameter wheel in the front, and a 12.7 cm diameter wheel in the back. The motor will be placed approximately 7 cm behind the front wheel. The design will be 30 cm in length, 13 cm in width, and 8 cm in height. The estimated mass for design 1 is 750 g. The estimated torque for design 1 is 4.75 Nm, and the estimated speed for this design is 0.35 m/s. All of the estimated dimensions are based on the motor properties and other information provided by our instructor. The advantage of this design is the proximity between the motor and the front wheel, which represents even weight throughout the vehicle. In addition, design 1 have a decent estimate of the velocity, which will make design 1 succeed in meeting the time limit in each round of the hill climber competition. One disadvantage of design 1 is that it has less torque, which means it will have difficulty climbing the hills with large inclination.

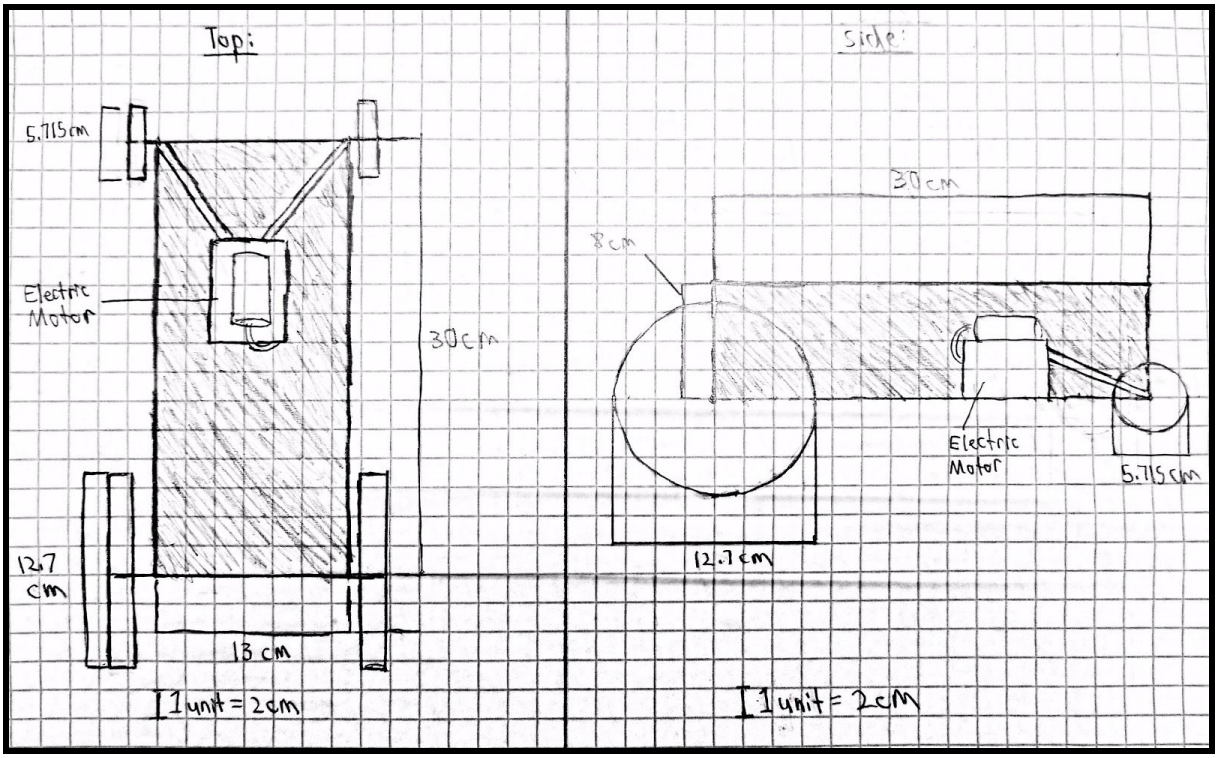

Figure 4: Design 1

4.2 Design 2

Design 2 will be a two-wheel drive K'nex car; the design will have two 12.7 cm diameter wheels in the front and two 4.13 cm diameter wheel in the back. The vehicle will be about 25 cm in length, 10 cm in width, and 18.7 cm in height. The motor will be placed approximately 2 cm behind the front wheels. The estimated mass of this design is 960 g. The estimated speed and torque for design 2 is 0.29m/s and 6.78 Nm. All of the estimated dimensions are based on the motor properties and other information provided by our instructor. The advantage of design 2 is that most of the vehicle weight is in the front, which is where the motor is placed; this is beneficial for the hill climber competition because less weight in the back represents more strength against the different inclinations of the hill.

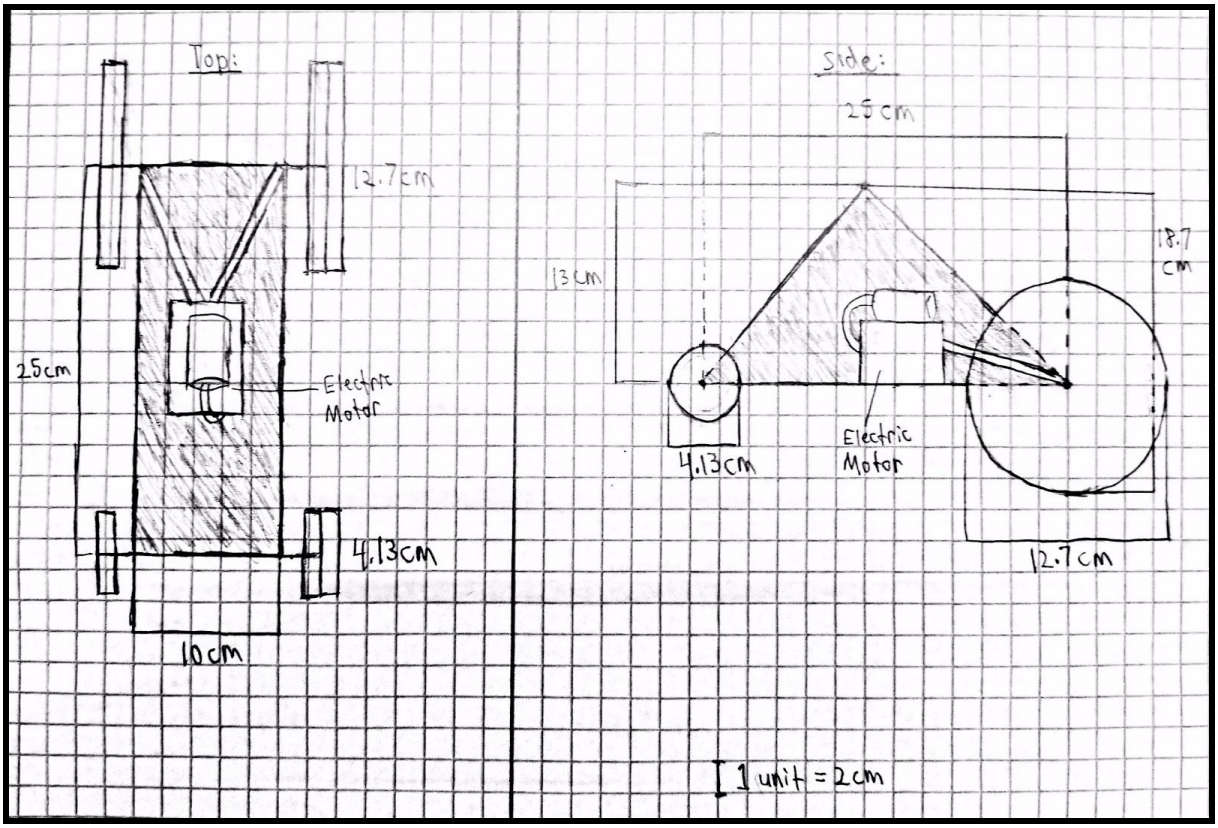

Figure 5: Design 2

4.3 Design 3

Design 3 is a four-wheel drive K'nex car. The design will have two 12.7 cm diameter wheels in the back and two 8.89 cm diameter wheels in the front. An engine will be attached to each of the car's axles, and the car will be approximately 27 cm in length, 14 cm wide, and 15 cm tall. The motors will be placed next to each other in the middle of the car to give the car an evenly distributed weight. The car has an estimated mass of 1000 grams. The estimated speed is about .2m/s, and the estimated torque is 9.5 Nm. All of the estimated measurements are based on the information provided to us by the professor. The advantage of this design is its high amount of torque. This design is intended to have the highest possible torque of all three designs, and it has an evenly distributed weight due to the positioning of the motors. The bigger wheels in the back allow the vehicle to travel more distance with one rotation of the wheel vs. one rotation of a smaller wheel. One disadvantage

of this design is that despite its high amount of torque, it has the lowest estimated speed out of all three designs.

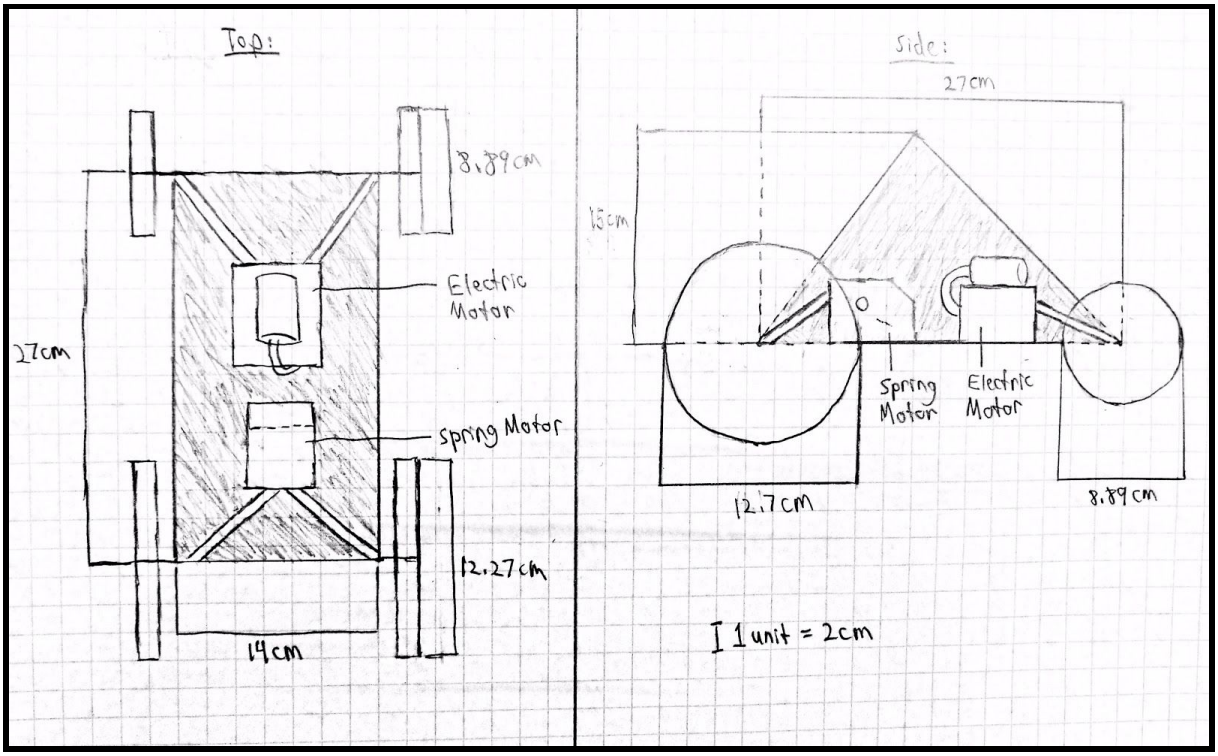

Figure 6: Design 3

5. Summary

The purpose of this project is to introduce fundamental engineering concepts to the students by giving them the opportunity to work with a client, just as in a professional situation. The objective of the project is to build a K'nex car that meets the required project specifications and performs the best at the hill climbing event assigned by our client, Dr. Moody. The car must follow all rules for its assigned event; it must also meet the feasibility criteria that are based on the project specification assigned by our client. Our final design will be the design with the highest merit scores from the merit criteria of vehicle mass, velocity, and torque. We proposed three separate preliminary designs, and, each has their strengths and weaknesses. We will choose one of these designs to build out of the given materials to compete in the hill climber event.