K’Nex Car Project
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Group 5

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1.Introduction

1.1 Project Goal

Abstract

The teams' goal in this project is to engineer a high quality K'Nex car to win a Hill Climb competition. The track this competition takes place on is 12'' wide and increases in elevation via 5 increments of 6''. As a result, the car must be designed to tackle steep inclines of up to ~22°. In designing the car, the team followed the rules set by both the competition and the team, that being the competition limitations and our merit criteria. The teams' merit criteria decided what designs would be used and tossed, they were speed, weight, and length, and weighed 50%, 30%, and 20% on merit score respectively. Of the three current feasible designs, the third iteration seems most likely to find success. As such, the team will test, redesign, and improve this design iteration to give the team the highest chance to win.

1. Introduction

1.1 Project Goal

The objective is to construct a K'Nex car that will compete in and win The Hill Climb. Multiple designs with varying parts and dimensions will aid in understanding how to construct a K'Nex Car capable of climbing an 8-foot-long track and reaching heights of up to 36 inches tall (illustrated in Figure 1.1). Once the final design is complete, it will be raced against the designs of competitors to determine if any improvements can be made. Through research and experimentation, a plan for winning the Hill Climb will be established.

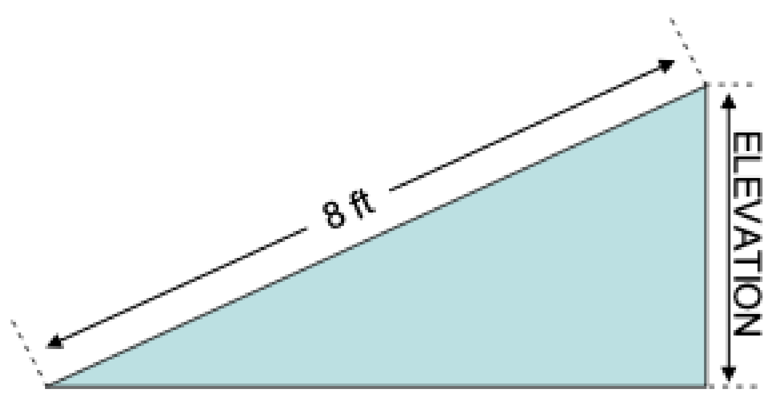


Figure 1.1 “The track is 8 ft long and the elevation increased up to 36 inches tall”

1.2 Rules for Competition

The Rules for the competitions is as follows; Vehicles will run in a side-by-side race format. The course will be four side-by-side lanes, ~12” wide and 8’ long. The surface will be covered with a texture paint to improve traction. The starting position of the course will be a 12”-long section of the lane. The finish line will be a line located ~6” from each end of the course. The race portion of the course will have a length of ~6.5 ft. The lanes of the course will be separated by vertical dividers. The entire set of lanes will be adjustable so that the angle of climb can be adjusted. The competition will be DOUBLE ELIMINATION format. Competitions will be allowed to last 90 seconds. Judging will be performed in the following manner: A contest will consist of all the uneliminated vehicles running the course at a fixed elevation. Six (6) contests are anticipated with runs at elevations of 6”, 12”, 18”, 24”, 30”, and 36” In the event that the majority of the vehicles cannot move a significant distance at a given elevation, the elevation increase increment will be reduced from 6” to 2”. The slowest vehicle in a heat will be eliminated. The vehicle traveling the least distance towards the finish line will be eliminated.

1.3 Project Timeline/Dates

Table 1.3

Project Timeline	Dates
K’Nex PDR Draft	September 9, 2022
K’Nex PDR	September 16, 2022
K’Nex CDR	October 7, 2022
K’nex Teammate Performance Rating	October 10, 2022

2.Vehicle Specification

The Vehicle specifications are as follows:

· No longer than 12” at the start of the competition
· No higher than 18” at the start of the competition
· Vehicles may ‘expand’ once the race commences
· Vehicle width cannot ever exceed lane width
· Vehicle must stay in its own lane
· Vehicle may not use rubber bands as a source of propulsion

3. Design Criteria:

3.1 Feasibility criteria: This comes from the vehicle speculations.

- The vehicle cannot be any longer than 12”.
- The vehicle cannot be any higher than 18”.
- The vehicle can expand once the race begins.
- The width of the vehicles cannot ever exceed the width of the lane (~12”).
- The vehicle must stay in its own lane.
- You cannot use rubber bands as propulsion for your vehicle.

3.2 Merit Criterion 1: Estimated Speed

As shown in figure 1, one of the three merit criterions that the team evaluated was speed.

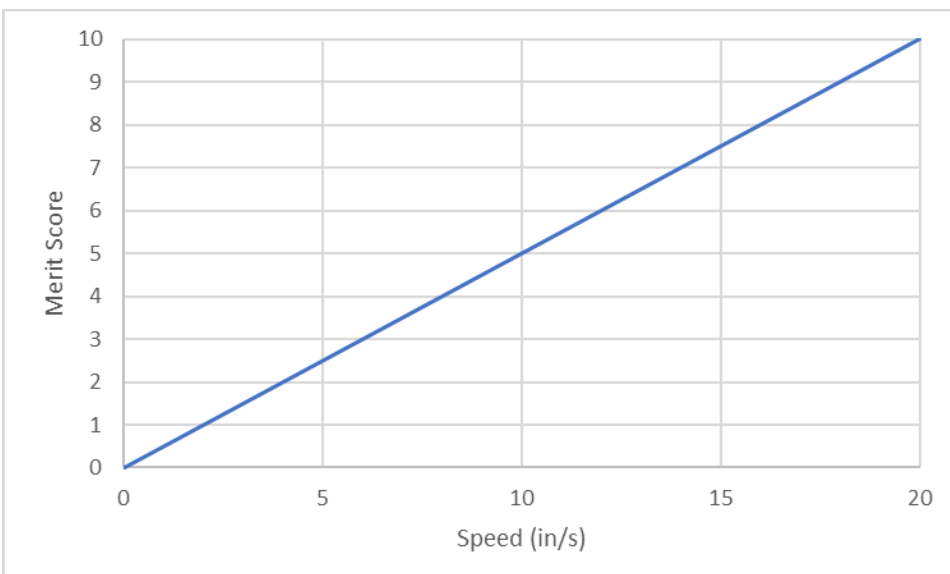


Figure 1: Merit Criterion 1 – Estimated Speed

Speed was one of the most voted criterions for this specific competition because it plays a huge part in helping to win the competition. The speed of the final design was 8.74 in/s. It was calculated by timing how long it takes to go 3 feet. Then the team divided 36 in by the time that was evaluated, which was 4.11 seconds to reach 3 feet. This was not the fastest car, but this was the fastest the car could go while still holding good torque to climb the highest slope. Speed was weighted 50% because it was the most important.

3.3 Merit Criterion 2: Estimated weight

As shown in figure 1, The second of the three merit criterions that the team evaluated on, was weight.

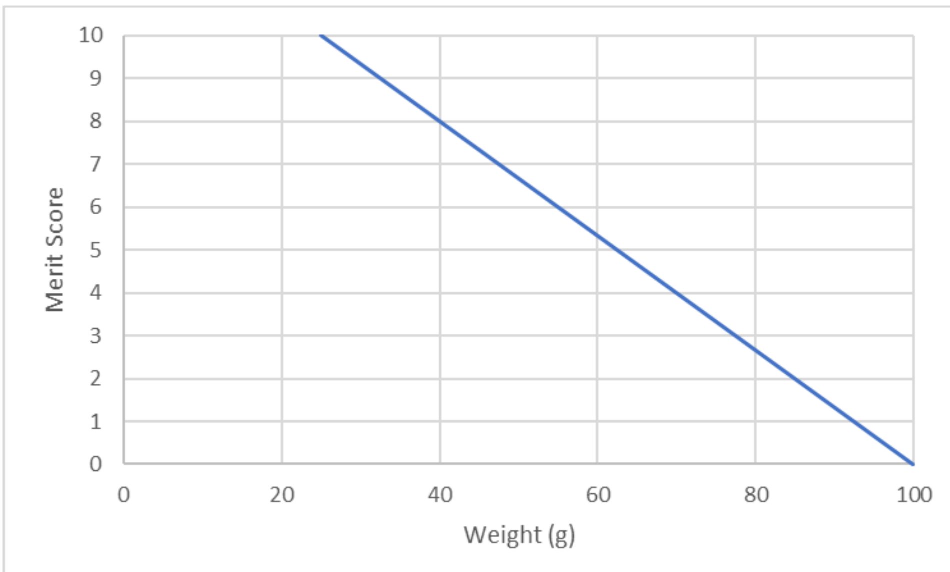


Figure 1: Merit Criterion 2 – Estimated Weight

Weight was the second criterion voted on for the competition. Weight played a huge part in improving speed and helped keep the car from falling backwards. The team lessened the weight by using smaller wheels in the front. The weight from the battery pack was then put on the front so that there would be an even weight distribution. This allowed for the car to climb 36” with ease without being close to falling over. The weight of the final design was 310g. This was found by weighing the car on a small scale. Weight was weighted 30% because it did a lot to help with speed and help to not fall over.

3.4 Merit Criterion 3: Estimated Length

As shown in figure 1, The third of the three merit criterions that the team evaluated on, was length.

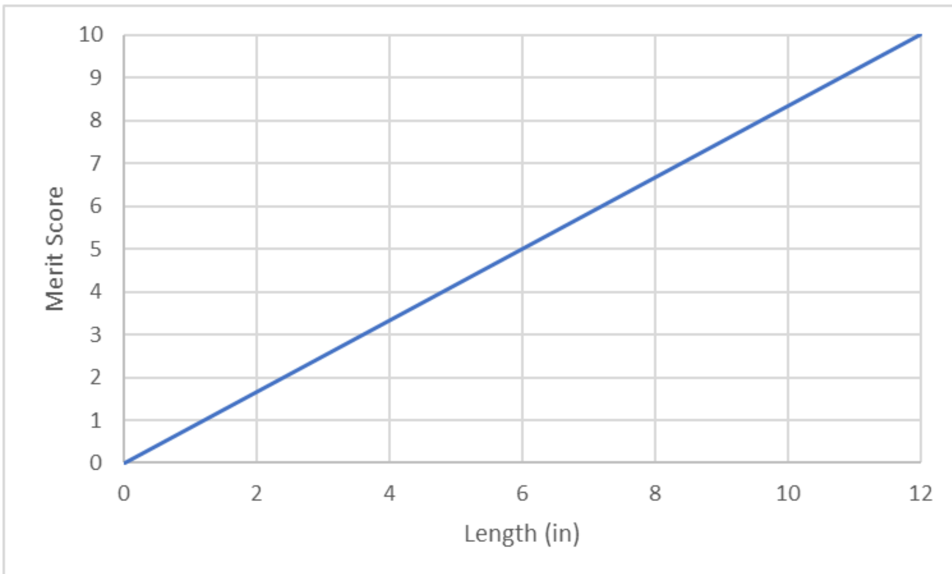


Figure 1: Merit Criterion 3 – Estimated Length

Length was big in helping the car to not fall over as easily. The team found that making the car towards the longer side gave the car a much better chance of not falling over. In testing on the track, a shorter car proved to have a greater chance of falling over at higher slopes such as 36”. Although the team at first thought length was not important, the more testing that was done showed otherwise. The length of the final design is 9 in. The team evaluated this by simply measuring the car with a yard stick. Length was weighted 20% because it only helped with keeping the car from falling over.

4. Selected Design:

4.1 Feasibility Analysis for Selected Design

This final design met all the feasibility criteria requirements as laid out in the vehicle specifications portion.

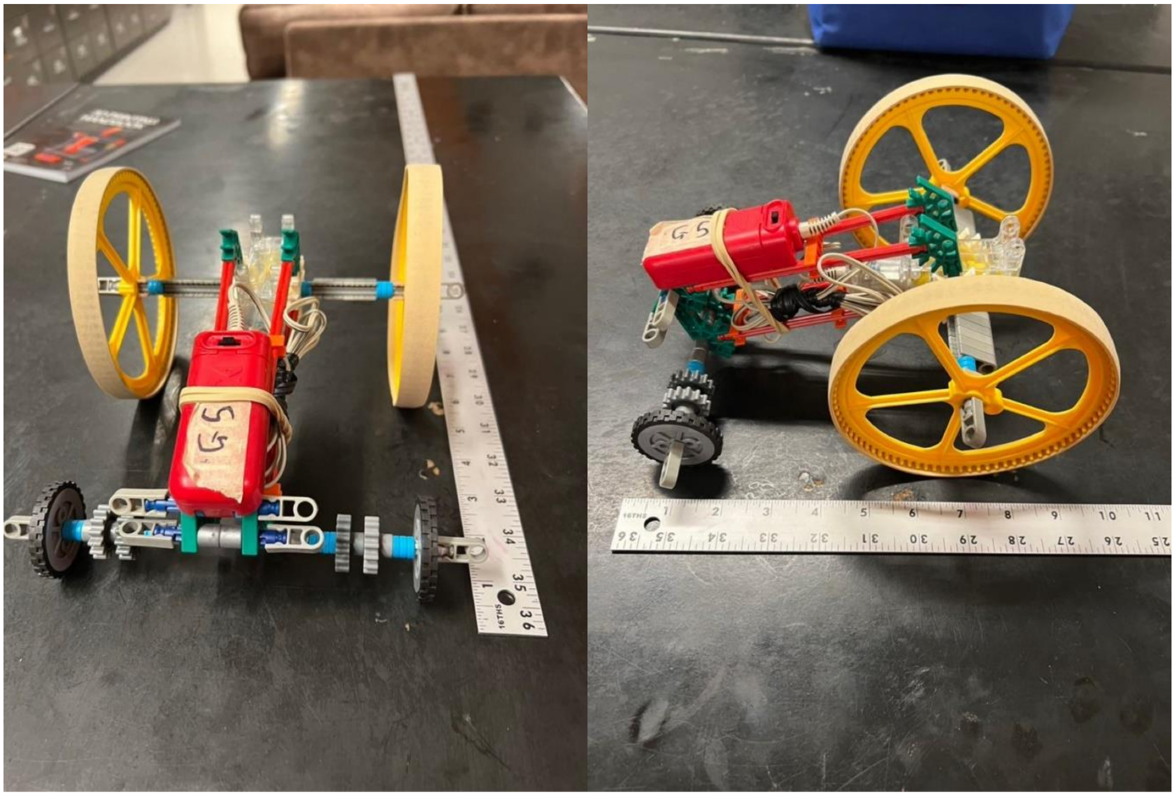


Figure 1: Photos of the Selected Design

<u>4.2 Description of Selected Design</u>

The Final Design used in the competition weighed 310g, was 9 inches long, 5.25 inches tall, 8.5 inches wide, and the top speed for it was approximately 8.74 inches/second. This car used the battery powered motor connected directly to the rear axle making it rear wheel drive and because no gears were used in this design it is geared down since there is a loss of speed for more torque. This car took around an hour to formulate the design and construct it. The cost for all the pieces for this car is $32.06.

<u>4.3 Merit Analysis for Selected Design</u>

Table 1: Selected Design Merit Analysis

	Specs	Weight	Score
Speed	8.74 in/s	50%	4
Weight	310g	30%	0
Length	9 inches	20%	7
Total Score			340

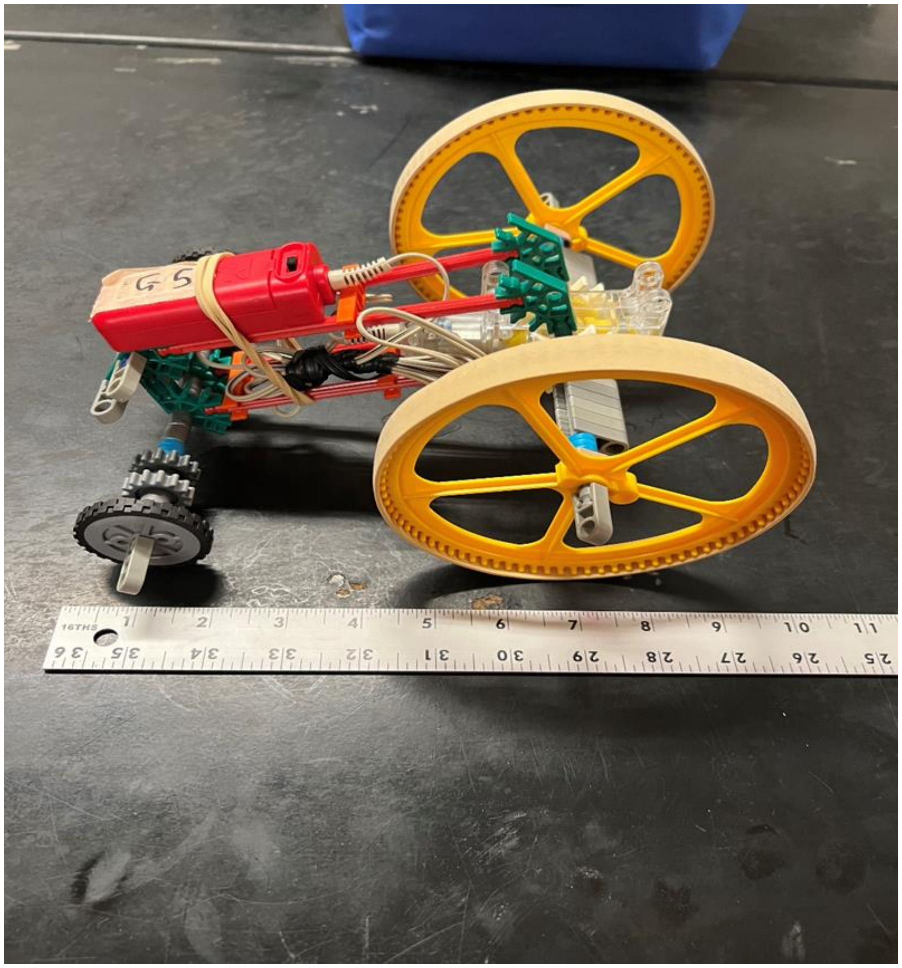
Because this Design wasn't the fastest with a speed of only 8.74in/s, it earned a lower merit score of 4. The weight of the cars was seen as negligible because the range made in class was only up to 100g which the car exceeded greatly because it weighed 310g so it earned a merit score of 0. The length of the car was higher on the merit curve, being 9 inches, so it earned a score of 7. After calculating the scores with the weights, the final design earned a total score of 340, which was seen as middle of the pack by the team, however, this design was the best.

5. Design Modifications:

The main thing the team noticed in the third design was that it was very inconsistent and not sturdy. Before competition day the team reinforced it and made sure that it was consistent when doing the tests. This resulted in weight gain, but the car did not lose much speed.

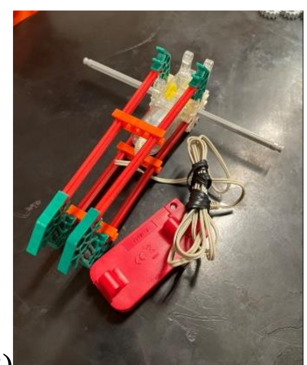
<u>Figure 1111 Design 3:</u>

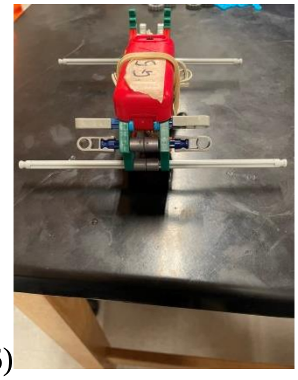
This is a picture of design 3. As you can see it only has 2 grey rods as a body. Therefore, the vehicle was not sturdy. You can also see that there are not enough spacers on the axles so the wheels could shift. The team found out this would cause unwanted veering left or right of the car. This design had a length of 11.5 inches, a width of 9 inches, a height of 5 inches, a weight of 371 g, and a speed of 9.16 in/s.

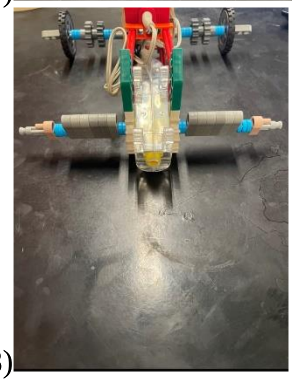


<u>Figure 1111 Final design:</u>
This is a picture of the final design. As you can see the team made the body of the car sturdier overall. More spacers were then added on the axels which lead to more consistent steering when testing the car on the track. The team also changed the front to smaller wheels. This helped the car climb the tallest setting (39”) easier on the track. This design had a length of 9 inches, a width of 8.5 inches, a height of 5.25 inches, a weight of 310 g, and a speed of 8.74 in/s. As you can see the final design is 61 g lighter which made the car lose .47 in/s in speed but allowed it to climb the highest track setting a lot easier.

Assembly instructions

Step 1)  Step 2)  Step 3) 

Step 4)Step 5)Step 6)

Step 7) Step 8) Step 9)

1. Budget Analysis:

<u>1.1 To-Be Assembled Kits</u>

The time it takes to sort all the parts into a kit is roughly 1 minute. Sorting all 1000 kits takes roughly 16.67 hours, paying the employees minimum wage at $7.25 an hour, accounting for benefits and overhead costs comes up to approximately $321.48 per employee per 1000 kits. Adding the calculated price of the parts, shipping, and overhead rates, which is $63,693 per 1000 kits, this comes to a grand total of $64,014.48 for 1000 To-Be Assembled Kits.

<u>1.2 Fully Assembled Kits</u>

The time it takes to sort all the parts into a kit and then build the kit is roughly 11 minutes. Sorting and building all 1000 kits takes roughly 183.33 hours, paying the employees minimum wage at $7.25 an hour, accounting for benefits and overhead costs comes up to approximately $3536.73 per employee per 1000 kits. Adding the calculated price of the parts, shipping, and overhead rates, which is $63,693 per 1000 kits, this comes to a grand total of $67,229.73 for 1000 Fully Assembled Kits.