Group: Hotel
Group Members: Aiden Shanks, Gavin Grundei, Aarush Maddula
School Year / Term: Junior

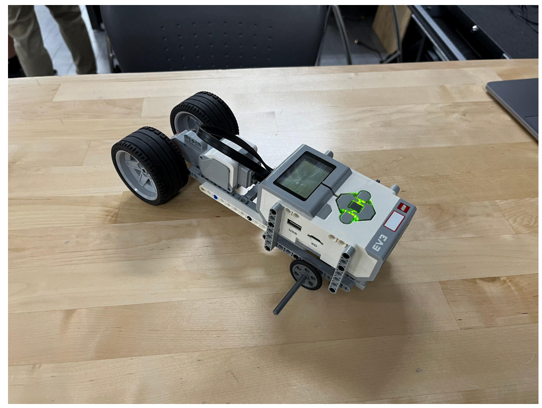
LEGO Dragster Project Report

Introduction

We were tasked with making a drag racer car that we would eventually race against others in a competition, where the fastest car to the finish line wins. To make the car, we were given an EV3 Lego kit that we would use to build our cars. Aiden Shanks, Gavin Grundei, and Aarush Maddula worked together during this project.

Task 1 - Investigating Wheel Size

Our group first started by building a basic vehicle where we can test various wheel sizes. Pictured on the right is a Lego car with an Ev3 brick on the front and 1 motor on the back, with the back 2 wheels attached directly to it.



To measure how effective each wheel size is, we decided to measure the speed of the car with each wheel type. To do that, we had programmed our car to run for 5 seconds and then measured how far each different wheel size traveled in that 5 seconds. We did 3 trials and averaged the distance traveled.

After that, we calculated the theoretical and actual speeds of each wheel size. To calculate our theoretical speed, we measured each wheel's diameter to find the circumference and multiplied the circumference by the rotational speed of the motor (2.5 rps). We then calculated the actual top speed by dividing the distance traveled by each wheel size by the 5 seconds it traveled.

After analyzing our data, we found that bigger wheels travel faster for both theoretical and actual speeds.

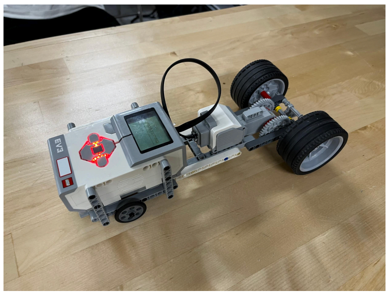
Data table: Distance traveled, Theoretical & Actual Speed for each wheel size

	Wheel Size (mm)			
	68.8	56	43.2	22.2
Trial 1 (cm)	264.16	213.36	168.91	95.25
Trial 2 (cm)	260.35	212.09	169.545	93.98
Trial 3 (cm)	261.62	210.82	168.275	93.98
Average (cm)	262.04	212.09	168.91	94.40

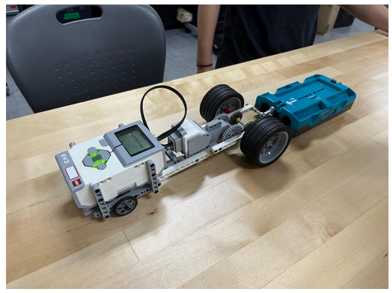
Theoretical Speed (cm/s)	54.04	43.98	33.93	17.46
Actual Speed (cm/s)	52.41	42.42	33.78	18.88

Task 2 - Investigating Gear Ratios

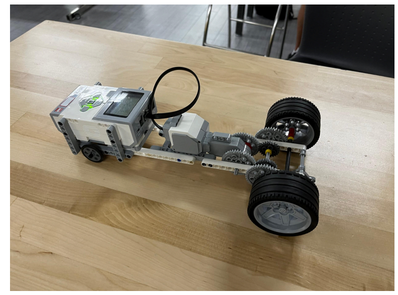
After considering wheel size, our next task was to calculate the best gear ratio for our car. We first found the theoretical top speed by multiplying the rps of the motor (2.5 rps) by the gear ratio and the circumference of the wheel, determined by measuring the diameter. To find the actual top speed, we set up four different gear ratios and connected a Vernier motion sensor cart for each. The images and results are shown below. To find the acceleration and the top speed, we used the Vernier software that connects to the cart to find the speed (max value of velocity vs time graph generated) and acceleration (slope of velocity vs time graph), shown in the data table below.



8:40 (1:5) Gear Ratio



24:40 (3:5) Gear Ratio



24:40 x 8:40 (3:25) Gear Ratio

Data received from Vernier Software

	8:40	24:40	8:24 x 24:40	24:40 x 8:40
Theoretical Top Speed (m/s)	2.702	0.901	2.702	4.503
Top Speed (m/s)	2.484	0.933	2.337	2.762
Acceleration (m/s/s)	0.7226	1.624	0.6569	0.289

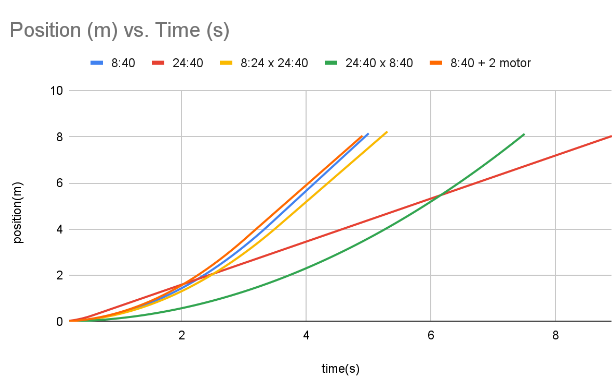
We found that:

1. As the gear ratio increases, acceleration increases, but top speed decreases
2. If the gear ratio is too high, the car won't move at all
3. Despite 8:40 & 8:24 x 24:40 having the same gear ratio, the performance was worse for 8:24 x 24:40
4. The theoretical top speed got less accurate with higher gear ratios

Task 3 - Modeling Car Performance

Prior to race day 1, we modeled the position of our car for each gear ratio throughout the race by using Matlab and Google Sheets to visualize the data, shown on the right. We used this to see which design reached the finish line first, helping us pick the best car.

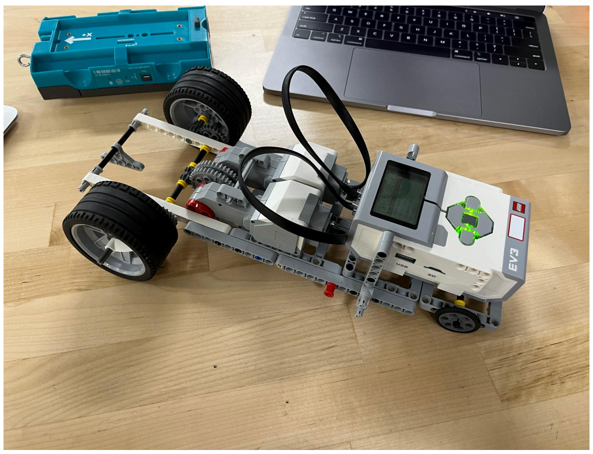
Because we were not limited to the number of motors we used, we decided to double up the amount we had before the first race by adding a motor to the back of the car, which we added to the model with an 8:40 ratio. This resulted in a minor improvement.



We looked at each of the data graphs for the gear ratios. Since this was an 8-foot race, we picked the one that reached 8 feet the fastest, which was the 8:40 ratio + 2 motors.

Race Day 1

Leading up to the race, we prepared our car by setting the gear ratio of our car to what we predicted would perform the best. We also decided to put one of the motors in the front and one in the back. We made this decision because it made sense to provide power to all 4 wheels for maximum traction.



Dual Motors in Back

All Wheel Drive

We tested our design by conducting a time trial, where we raced the car on the 8 foot track and timed the results

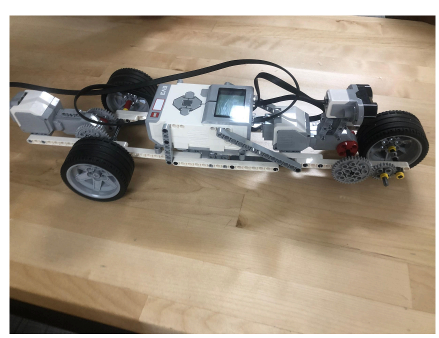
Datatable: Time Trial Data

Trial	Time (s)
1	1.5
2	1.75
3	1.69
4	1.59
Average	1.63

We raced our cars and almost won, but we lost to the winner by a very close margin.

Task 4 - Investigating Factors for Car Performance

After race day 1, we investigated our car and decided that the car may have been too heavy. We came in second place, losing by only a hair. Both our car and the winning car had the same amount of motors and the same gear ratio; however, the opponent's car was slightly lighter. To compensate for the greater weight, we removed one of the wheels in the front creating our final three-wheel design, pictured to the right.



Race Day 2

After changing the wheel count, we decided to keep the previous gear ratio as the race track for day 2 wasn't much longer. The results of the race were successful as we won day 2 where we finished ahead of the opponent's car by just a couple centimeters.

We conducted another time trial before the race:

Trial	Time (s)
1	3.28
2	3.99
3	3.71
4	3.75
Average	3.68

Conclusion

Our group successfully built, optimized, and raced a Lego EV3 drag racer during this Engineering project. To achieve this, we first started our design process with testing various wheel sizes by finding the speed of the car with various wheels, where we learned that bigger wheels are faster. Then, we tested various gear ratios by finding the acceleration and top speed of the car, where we learned that a gear ratio that isn't too low or too high, like 8:40, has a good balance between top speed and acceleration. We also tested adding 2 motors to our design, which we learned had a small improvement. We took this data and modeled it using Matlab to find a design that would reach the 8 foot finish line the quickest. After moving the motors to the front and back, we raced to place a close 2nd place. We reduced the weight of the car by removing a wheel to help improve performance, which helped us secure a day 2 win.

Overall, our group learned a lot from this project, like the effect of wheel sizes, gear ratios, and motors on performance. If we had to do this project again, I might use bigger wheels and test more gear ratios that are not too high or low to find a gear ratio that performs better. I might try using the new Spike bot system as they are lighter than the Ev3 system. I also might test changing other factors of the car, like the shape of the body or more powerful motors.