Drag Racer Lab Report: Take 2

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Introduction:

In take 1 of this lab, we were tasked to plan and build our Lego Drag Racer without gears. We recorded speeds, the building process, and other data we collected while assembling it. Take 2 of the drag racer lab, however, required us to use gears, and thus we had to completely overhaul our drag racer to incorporate these new guidelines. Gears significantly increased the speed of our drag racer, but also the difficulty of our assembly. The members of our group were still Jack, Christian, and Lokesh.

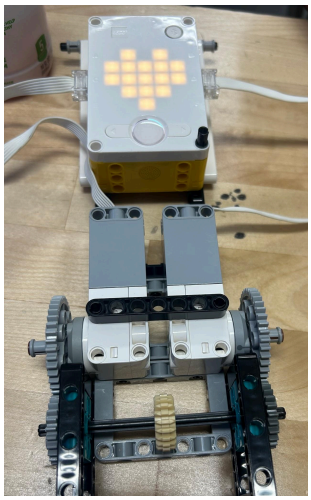
Engineering Notebook:

Our drag racer, which we completed from the first lab report, left much room for improvement. In order to accomplish a design where gears could be implemented, we had to construct an entirely new base. We dismantled our original design and started brainstorming ideas for where we could fit the gears.

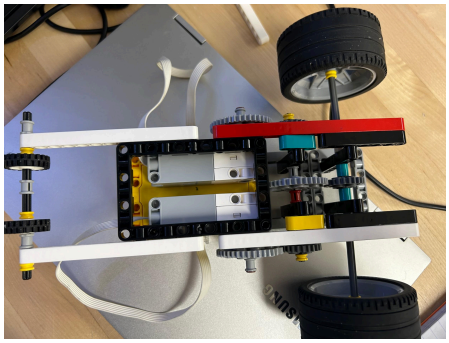
Design Process:

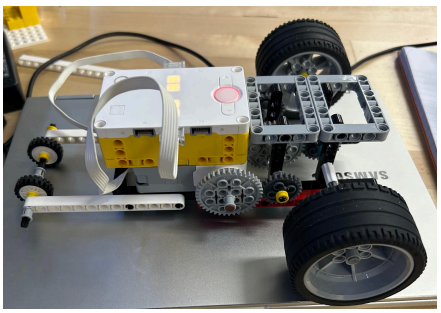
Our first idea was to leave the front the same, but move the motors to the middle of the car and have the gears run from the middle to the back wheels. This, however, failed to work as the back lacked enough structure to place the gears and axles, and was also too short for the big 40-tooth gears. Our second idea, and the one we landed on, was to put the hub on top of the gears. This gave us more height for the gears to fit in, and also improved the structure of the racer in the back, allowing for axles to fit more smoothly. Finally, we decided to have a gear set on each motor, but another set in the middle attached to an axle off the driven gear. We believed this would allow us to hold finer gear ratios that would optimize performance.

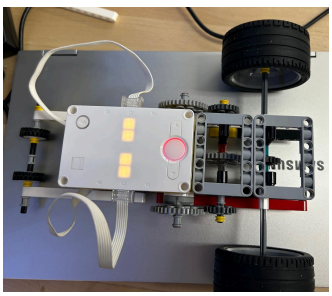
Our First Design



Our Second Design







Data and Models:

Once we built the car, we began testing it and calculated its top speed and acceleration. The table below shows our individual results for each gear ratio, along with their average velocity, found by taking the 22.74-meter course divided by the average time. Note: Our third gear ratio was a 1:10 gear ratio and did not have enough torque to move.

Gear Ratio	3:5	9:25	1:10	1:5
Run 1 (s)	3.04	1.96	did not move	1.73
Run 2 (s)	2.89	2.19	too much torque	2.01
Run 3 (s)	3.13	1.91		1.85
Avg Run Time (s)	3.02	2.02		1.863
Velocity (m/s)	0.9072847682	1.356435644		1.470483005

After finding the true velocity, we began finding the theoretical velocity and acceleration, as well as the theoretical time it would take the racer to travel a 2, 4, 6, and 8 meter course. First, we found that LEGO motors have an output rpm of 155. Then, using the gear ratios, we calculate the new rotations per minute on the back wheels. Next, we converted rpm to m/s through a long series of train-track unit conversions. We took the rotations and converted them into meters using the circumference of the wheels, and divided the minutes by 60 into seconds. Once we found our theoretical velocity, we could use simple physics equations to find our acceleration. We took the equation $x = 1/2at^2$, and found that $a = 2(2.74)/t^2$. Finally, we used the equation $t = \sqrt{2x/a}$ to find the time it would take the car to travel each distance.

Gear Ratio	RPM	New RPM	Unit Conversions	theoretical velocity (m/s)	avg time (s)	acceleration (m/s²)	2-meter course	4-meter course	6-meter course	8-meter course
3:5	155	258.33	0.0035605	0.92	3.02	0.60	2.58	3.65	4.47	5.16
9:25	155	430.56	0.0035605	1.53	2.02	1.34	1.72	2.44	2.99	3.45
1:10	The drag racer did not move as there was not enough torque.									
1:5	155	775	0.0035605	2.76	1.863	1.58	1.59	2.25	2.76	3.18

Competition:

When we put our drag racer to the test against the other racers, we were surprisingly shocked by how well it went. Our racers' speed was fairly fast compared to the other racers, and we only lost due to technicalities. Our car put up a good fight and drove in a straight line. The other racers either drove off course or could not keep up. We did not have those problems. In the final, Bravo seemed to be the same speed as us, but it had a longer nose, which ended up helping toward its victory. We came in 2nd place in both competitions and couldn’t be happier with our work.

Conclusion:

For this lab, we were tasked with expanding upon our previous attempt at building a LEGO drag racer. This time, we had to modify our drag racer to include the use of gears. Unfortunately, our previous design did not harbor gears very well, and thus we had to disassemble and reassemble our car. We were able to make a successful car with gears on our second try, and were able to collect our data and complete our calculations with no errors. The only small mistake we made was overlooking the fact that a 1:10 gear ratio would not have enough torque to move the car. We concluded that a 1:5 gear ratio worked best as it had a fast enough top speed without struggling to accelerate. If we could redo one thing, we would’ve made a simpler gear train. We believed that by making a complex gear train, we could achieve finer gear ratios. Unfortunately, this did not turn out to be necessary, and thus we wish we had made it simpler. Overall, this project was successful, and we are happy with our results.