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Abstract

This experiment finds the best surface for a car with rubber tires to reach a destination in the least amount of time with velocity and rolling resistance being taken into account. The car was equipped with an actuator and traveled on surfaces with different rolling resistances in a distance of 68.58 cm between two light sensors which captured time. The test showed that the concrete had the highest average velocity with 32.1322 cm/sec on a surface with .1 rolling resistance enabling the car to go the fastest. While the sand had the lowest average velocity with 17.4450 cm/sec on a surface with .3 rolling resistance enabling the car to go the slowest.

Introduction

Based on the observation of the different rolling resistances for each surface, the hypothesis for this experiment is that a car with rubber tires will move the fastest on a surface with the lowest rolling resistance and slowest on a surface with the highest rolling resistance.This is due to the rolling resistance being the opposing force to any moving object such as a ball.

The different surface materials are sand, organic clay breaker soil conditioner with gypsum (OCSG), concrete, carpet, and gravel. The car is equipped with an actuator in order for the rubber tires to move as a two wheel drive. In order for time to be captured for the car there are two sensors that are placed 68.58 cm apart from each other. The last essential component is the EV3 device which plays the role of storing a program needed to make the sensors and actuator work.

In this experiment the average velocity will be taken into account to measure how far a rubber tire car moves in a specific distance on different surfaces. The average velocity will be the average of all the velocities of each trial. Additionally, the calculation for this will be the velocity=distance/time. The last aspect being taken into account will be rolling resistance. The

rolling resistance will be essential to consider the different forces that go against the moving car. For example the rolling resistance for concrete is .1.

Materials

Cardboard Box
Ethernet Cables
Actuators
Two Color Sensors
Two EV3 devices
Gravel
Mindstorm Software
sand
concrete(parking)
carpet
organic clay breaker soil with gypsum (OCSG)
USB cable
laptop
Lego car with rubber tires
Tape
plastic tarp
safety pins
styrofoam rails
Scissors

The essential materials are shown in figure-1.

Figure-1 Materials for the experiment. This figure includes the picture of the actuator, concrete, carpet, sand, lego car with rubber tires, cardboard box, OCSG, light sensors, and gravel.

Procedures

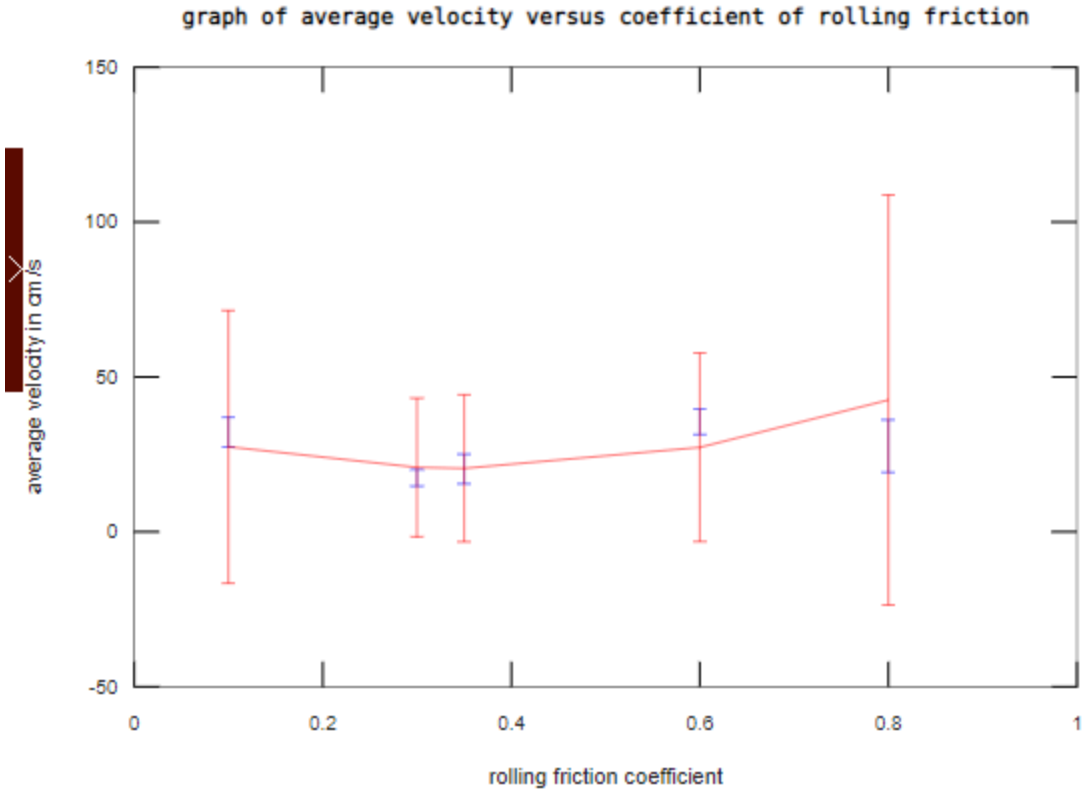
1. Gather all materials
2. Build an open rectangular box from cardboard with the dimensions of 121.92cmx96.52cmx17.78cm.
3. Put plastic at the bottom of the box to dispose of the material easily.
4. Tape the plastic down to fit the structure of the box.

5. Mark down the height along the perimeters of the box at 1.27 cm to ensure that the materials used for the surface are leveled up.
6. Pour the different contents you want to use in the box and ensure that they are leveled out.
7. Place styrofoam rails on top of the OCSG, sand, and gravel to prevent swaying of the vehicle.
8. Once the box is set up, create two programs on the mindstorm software for an actuator for the car and for the sensors used to detect time as shown in figure-1 and figure-2.
9. Connect the first EV3 device for the actuator using a USB cable.
10. Download the program into the EV3 device for the actuator.
11. Once the program is downloaded disconnect the EV3 device from the computer and then attach the EV3 device on the rubber tire car as shown in figure-3.
12. Connect the second EV3 device for the color sensors using a USB cable.
13. Download the program for the color sensors on the EV3 device.
14. Once the program is downloaded place the second EV3 device in the box and attach to color sensors to the EV3 device.
15. As the EV3 device is in the box separate the two sensors 68.58 cm apart making a good distance for the car travel.
16. Place the car behind the first sensor and activate the sensors by clicking play on the mindstorm software.
17. After the sensors are activated, press play on the EV3 device attached on top of the car for it to go to the second sensor to be recorded on the laptop.
18. Once you have completed five trials for each material on the surface upload the data on microsoft word
19. For the last surfaces, concrete and carpet, this will not be in the box so remove the car and sensors.
20. Place the sensors 68.58 cm apart from one another and begin testing on the concrete and carpet.
21. Complete five trials for each and record the data on microsoft word.

Results

The results are shown in the table (table 2) in the appendix with with five trials of data for each surface giving a reasonable error as shown.

$(102.18 \pm 90.2)x^2 + (-89.29 \pm 100.24)x + (17.215 \pm 16.71)$



The rolling resistances for the surfaces are shown on table-1

Table-1

Surfaces	Sand	Gravel	Carpet/Rug	Concrete	Gypsum
Rolling Resistance	0.3	0.6	0.8	0.1	0.35

Discussion

The hypothesis was incorrect. Although the the rolling resistance is high it does not result to a higher velocity. Aside from the hypothesis the most unusual feature was the fact that sand only had a .3 rolling resistance but had the lowest velocity and gravel had .6 rolling resistance but had the highest velocity. For the actual experiment itself the problem that was faced was for finding the x-axis and y axis. Originally the plan for the experiment was time over the coefficient of rolling resistance. However, calculating time was not enough so velocity was required. Lastly, the best way to improve the experiment would be to take into account other forces other than rolling resistance.

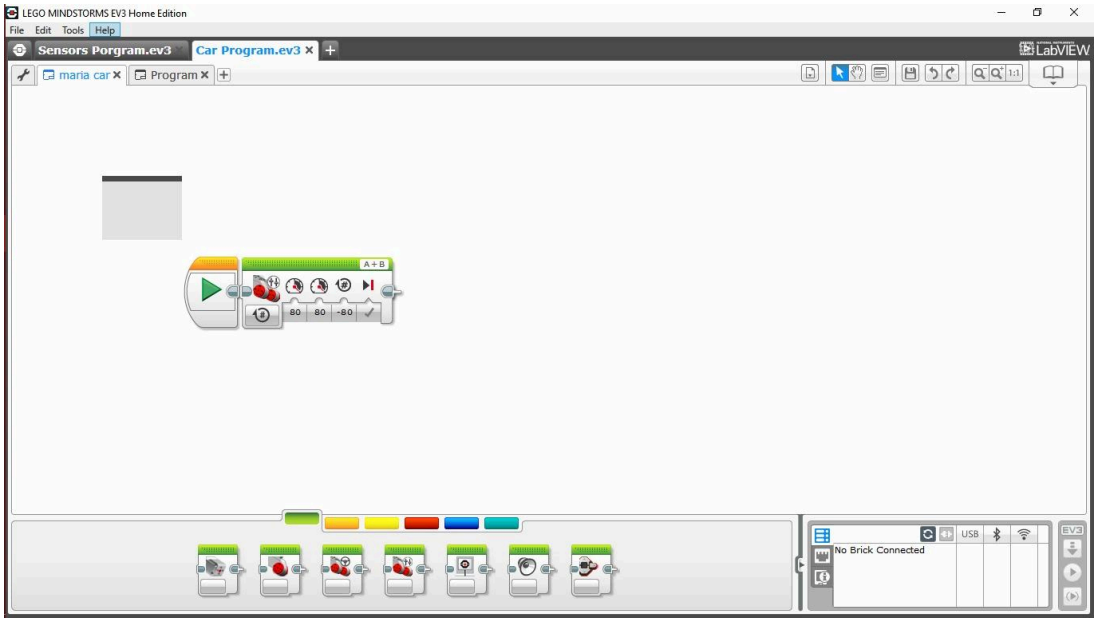


Figure-2 Program on the mindstorm software for actuators.

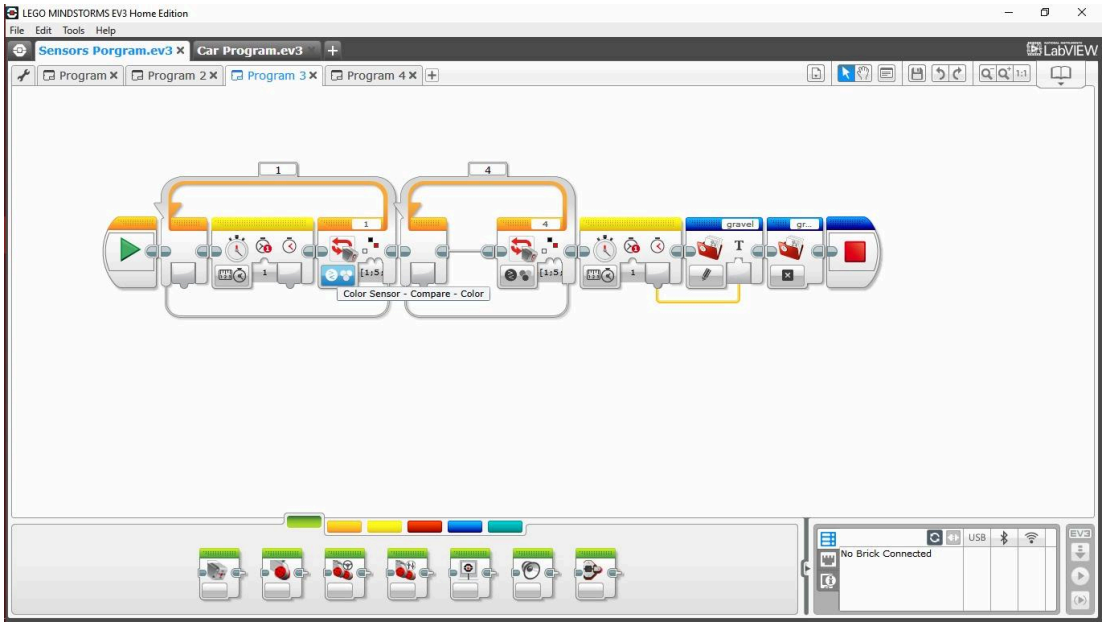


Figure-3 The program made for the sensors.

Conclusion

In the distance of 68.58 cm between two color sensors, the rubber tired car moves the fastest on gravel since it results in the highest average velocity. Furthermore, the rubber tired car moves the slowest on sand since it results in the lowest average velocity.

Reference

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Appendix

Table 2: Experiment times

	Sand	Gravel	Carpet/Rug	Concrete	Gypsum
T1	5.17secs	1.95secs	3.14secs	2.01secs	3.158secs
T2	3.68secs	1.924secs	2.59secs	2.33secs	2.90secs
T3	3.75secs	2.362secs	1.65secs	2.75secs	2.68secs
T4	4.11secs	2.2secs	3.44secs	1.903secs	4.65secs
T5	3.37secs	2.04secs	2.39secs	1.89secs	4.34secs
Coefficient of Rolling Friction	0.3	0.6	0.8	0.1	0.35

Table 3: Velocity

	Sand	Gravel	Carpet/Rug	Concrete	Gypsum
V1	13.2650cm/sec	35.1692cm/sec	21.8408cm/sec	34.1194cm/sec	21.7163 cm/sec
V2	18.6359cm/sec	35.6445cm/sec	26.4788cm/sec	29.4335cm/sec	23.6483cm/sec
V3	18.2880cm/sec	29.0347cm/sec	41.567cm/sec	25.1209cm/sec	25.5896cm/sec

V4	16.6861cm/sec	31.1727cm/sec	19.9360cm/sec	36.0378cm/sec	14.7484cm/sec
V5	20.3503cm/sec	33.6176cm/sec	18.6946cm/sec	36.2857cm/sec	15.8018cm/sec
Average Velocity	17.4450cm/sec	32.9277cm/sec	27.70276cm/sec	32.19946cm/sec	20.30088cm/sec