

Rubber Band Race Car

Physical Science Unit

Using LEGO Mindstorms NXT

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Overview:

Through a series of hands-on activities, students will design a rubber band powered car in order to explore **position** and **motion**. Students will experiment with car design in order to identify how different aspects of **technological design** will affect the distance the car travels. Students will conduct **scientific inquiries** in order to measure how changes in the car's design affect the distance traveled.

National Standards Addressed

[NS.K-4.1](#) SCIENCE AS INQUIRY

As a result of activities in grades K-4, all students should develop

- Abilities necessary to do **scientific inquiry**
- Understanding about **scientific inquiry**

[NS.K-4.2](#) PHYSICAL SCIENCE

As a result of the activities in grades K-4, all students should develop an understanding of

- **Position** and **motion of objects**

[NS.K-4.5](#) SCIENCE AND TECHNOLOGY

As a result of activities in grades K-4, all students should develop

- Abilities of **technological design**
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

Washington State Standards Addressed

EALR 2: INQUIRY

- K-1 INQD Scientists report on their investigations to other scientists, using drawings and words.
 - Students will report observations of simple investigations using drawing and simple sentences.
 - Students will listen to and use observations made by other students.
- K-1 INQF All scientific observations must be reported honestly and accurately.
 - Students will record observations (evidence) honestly and accurately.

EALR 4: PHYSICAL SCIENCE

- K-1 PS1C Motion is defined as a change in position over time.
 - Students will demonstrate motion by moving an object or part of a student's body and explain that motion means a change in position.
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Prior Knowledge

Have students explore with LEGO kits in small groups. Allowing students to investigate and create with the LEGOs prior to the lesson will not only increase their proficiency level in assembly with the LEGO kits, but will encourage them to stay on task during the unit (by allowing for curious play time in advance). It will also give you a broad overview of which groups may need more assistance with assembly.

Vocabulary Building

Discuss the following words and then post the words and the definitions on a word wall, overhead or chalk board:

- | | |
|----------|---------------|
| • Axel | • Position |
| • Car | • Rubber Band |
| • Design | • Wheels |
| • Motion | • LEGO |

Ask students to consider the difference between position and motion. In order to quickly assess understanding, have students play a quick game of position and motion. When you say position, have students show with their bodies an example of position. When you say motion, have students show an example of motion.

Engagement

Ask students to think/pair/share some different types of cars that they have been in. Have students think about the different parts of a car. Create a list on the board.

Select and read one of the following books aloud:

If I Built a Car (Paperback)
by [Chris Van Dusen](#)

Rattletrap Car (Paperback)
by [Phyllis Root](#)

Cool Cars (Amazing Machines) (Hardcover)

by [Tony Mitton](#)

At the end of the story, have the students add to the class list of car parts. Then, ask students to think about what parts are most important to a car's ability for motion. Remind students to think about what part all cars have in common (body, wheels, etc.) as versus what parts are different (shape, color, number of doors) Have students circle the parts they feel a car must have in order to be able to move easily.

Further Brainstorming Excitement

If you built a car, what would it be like?

What helps a car to move?

Explain to the students that today they are going to not only have the opportunity to build their *own* car, but see how their design changes affect its motion!

Summative Assessments

Science as Inquiry

As a class, evaluate and document how far a car will travel using three different wheel sizes. Create a graph that shows how the wheel size affected how far the car traveled. Compare and contrast the results documented on the graph as a class. Based on the results, ask students to predict what would happen if the wheels got even bigger? Smaller? No Wheels?

Science and Technology

Have students create a drawing that illustrates how changing the design of their car, changed how far their car traveled.

Physical Science

Ask students to compose one sentence that explains how their LEGO car illustrated both position and motion.

Leveled Instruction

Beginner

Have students work in small groups for each activity. Build the LEGO cars in advance and provide one completed car to each group.

Intermediate

Have students work in pairs for each activity. Complete steps one through three for the students. Provide partially finished cars to each pair of students.

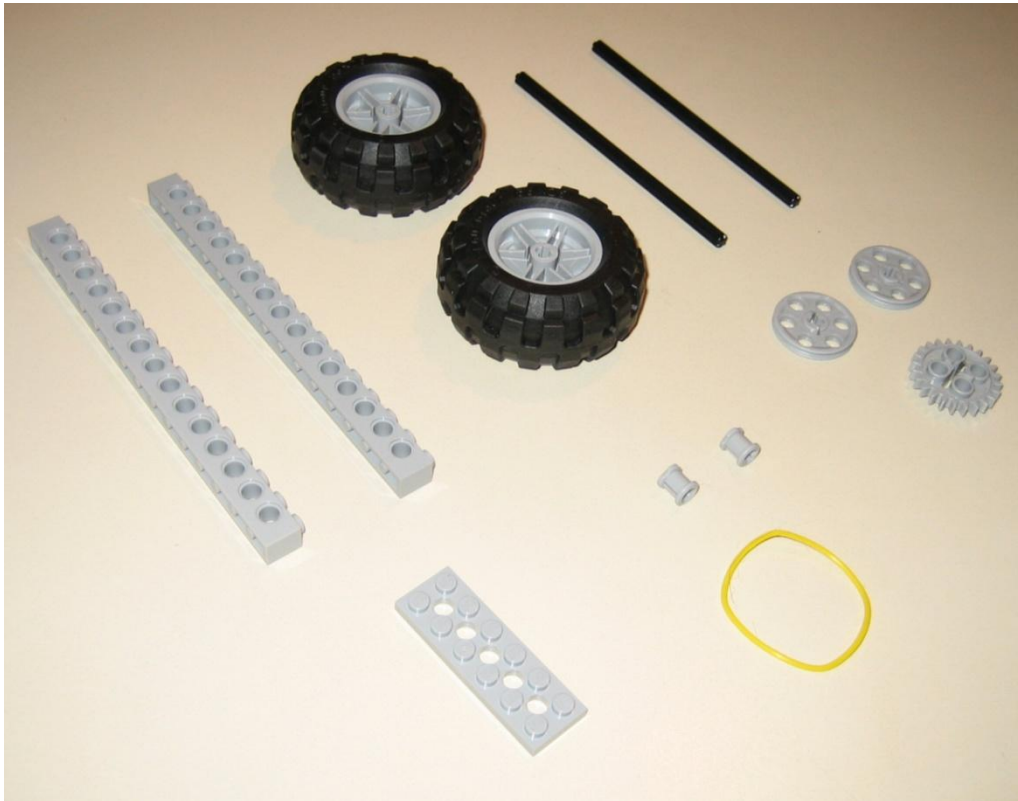
Advanced

Set up the LEGO inquiry as a science station. Have each student move through the station independently. Have students move to small groups in order to share results and exchange ideas.

Building Instructions

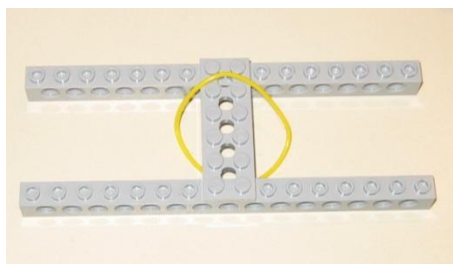
Build a simple Rubber Band Car in the following steps:

LEGO Parts needed:



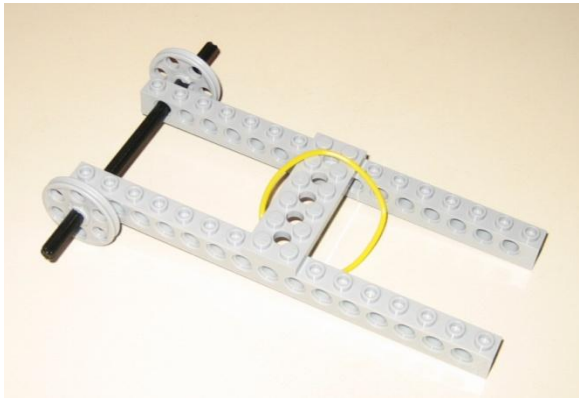
1. Build the main car body with the rubber band connection:

- a. Use the **yellow rubber band**, which is included in the LEGO kits, and connect it in the exact middle of the car body.

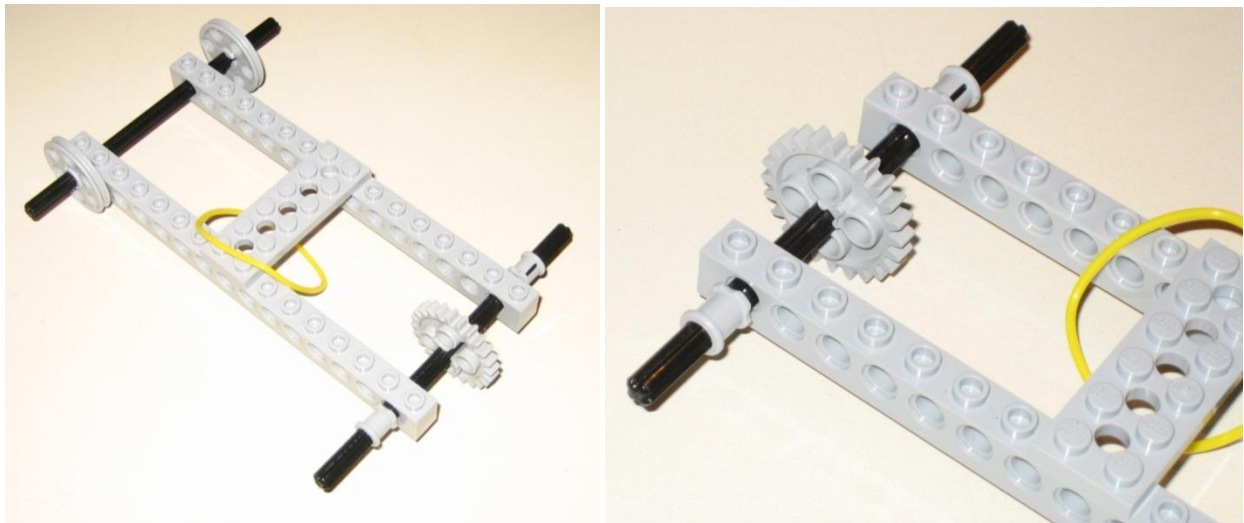


2. Add the front wheel axle:

- a. Make sure the wheels can spin freely – try rotating the wheels. Make sure the wheels don't rub against the body of the car.

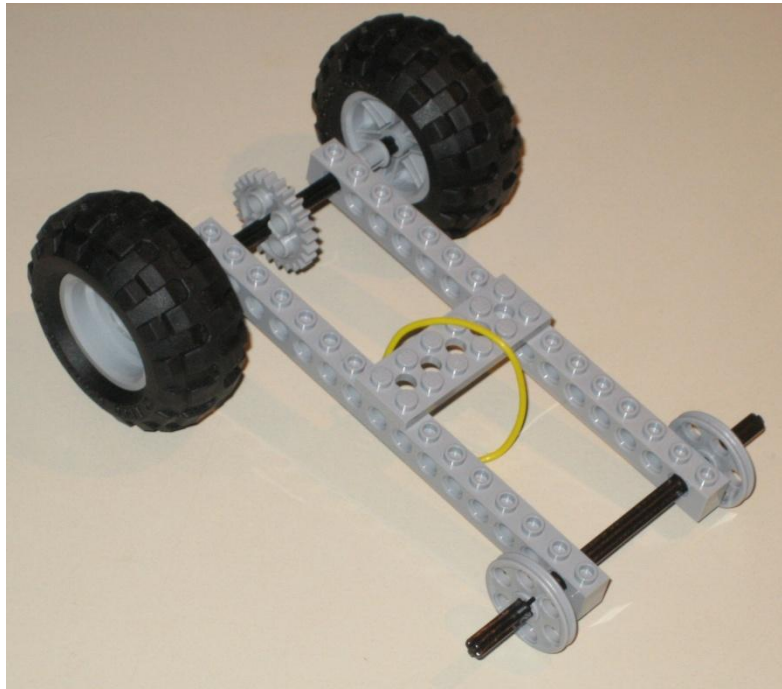


3. Add the rear wheel axle, with a gear that will hold and wind up the rubber band:



4. Add the rear wheels to the axle:

- a. Make sure the wheels can spin freely – try rotating the wheels. Make sure the wheels and the connecting pegs don't rub against the body of the car.



Scientific Inquiry Instructions

For each activity, follow these steps for conducting the inquiry:

(Note: the first activity is an intro to building the Rubber Band Car, and doesn't test different design options)

A. Discuss the Inquiry

Discuss the design option being tested in this activity

- Explain that you are going to build 2 cars that are the same except for one part. You will try out 2 car design options and test each option to see how it affects the distance that the car travels. (i.e. bigger and smaller wheels)
- Discuss the properties of each option. Compare the 2 cars and record the similarities and differences between the design options.
 - What is the same about these design options?
 - What is different about these design options?
 - Encourage students to think about different properties, such as the materials of the parts, size, weight, shape, and how it moves
 - Choose a writing activity (or do both if time permits):
 - Students draw pictures and diagrams of the different design choices, labeling and describing the properties of each.
 - Use a word chart on a board or large poster paper: draw one column for each option tested. Write down words describing each option in its column. Circle similarities between options, highlight or mark differences
- Ask the students to predict which of the options will make the car go farther or if they will be the same.

B. Build the Rubber Band Cars

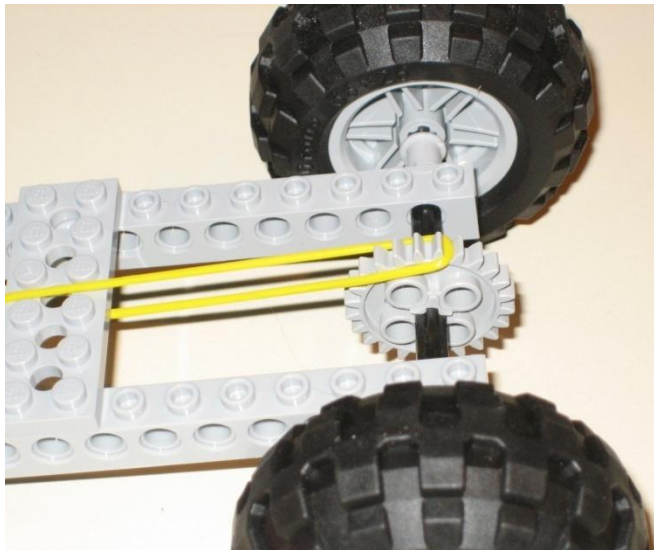
Build 2 (or more) Rubber Band Cars, one with each design option being tested.

- Depending on time:
 - You can pair up students and each group builds a car with a different option
 - OR you can build the cars together as a whole group with the teacher leading
 - OR you can have the cars pre-built before the activity starts
- If you have more than 2 groups building cars, assign half of them to use one of the options being tested (i.e. the big wheels) and the other half to use the other option (i.e. small wheels). Or you can test more than 2 options if you have the right parts (for example, 3 different sized wheels).
- See Building Instructions section

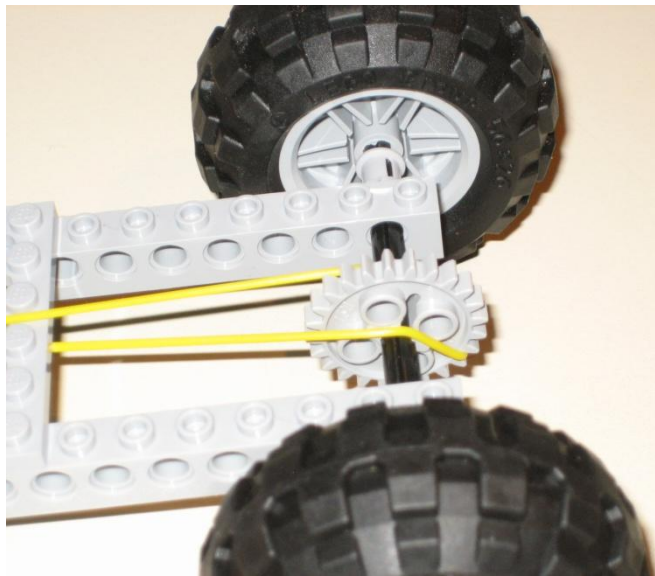
C. Test the Rubber Band Cars

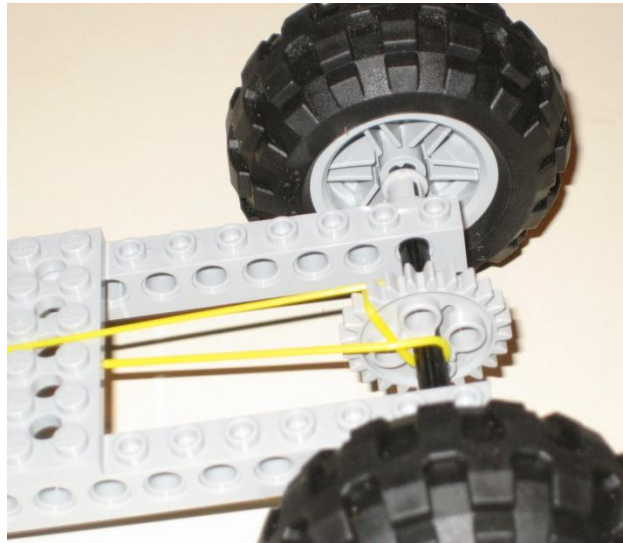
Test all of the cars together as a group, with the teacher leading the tests

- Mark a starting point with tape
- Load the rubber band onto the gear, while the car is on the ground:

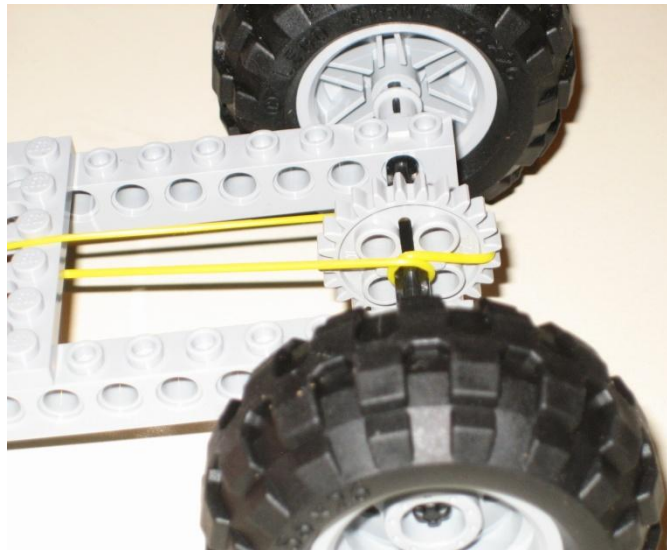


- Then pull the car backward on the ground to wind the rubber band around the gear:





- Wind for 1 full rotation of the wheels, until the rubber band is lined up straight across the gear like this:



- Place the car at the starting line; make sure to hold the wheels & the car when you move it so that the rubber band stays wound.
- Release the car by letting go. Let the car drive until it stops on its own (don't get in the way!)
- Measure from starting line to the car's stopping point (at the front of the car)
- Record the distance the car traveled in this test
- Run multiple tests for each car/design option (3-5 trial runs)
 - Write down the distance for each trial run

D. Fair Tests

- Discuss with the student about running fair tests. Explain that you need to keep everything equal in the tests except the one part you are testing.
- Make sure that these things are the same between your 2 cars you are testing:
 - Starting line

- End measuring point on the car (always measure to the front of the car)
- Release – make sure the rubber band is “wound” around the same amount. Use one full rotation. (Except in Activity #3 where the test is about winding the rubber band)
- Same path – the cars run on the same part of the floor & in the same direction (in case the floor is sloped slightly or different textures to the floor material, etc.)
- When testing one part, make sure all the other parts are the same.
- Make sure the beam that the rubber band is around is the same distance away from the gear in both cars.

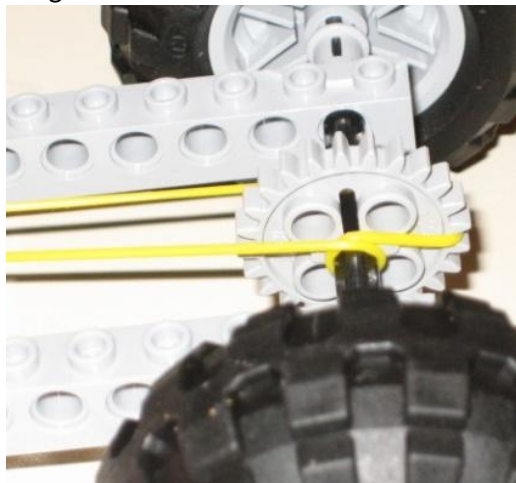
E. Analyze and discuss results

Compare results for each design option

- Create a bar or line graph of the results
 - Make a point or block line on a graph for each trial; the height of the bar or point corresponds to the distance that the car traveled in that trial.
 - Make all the trials with the same design option the same color. For example, all the trials with the small wheels are blue bars on the graph and the trials with the big wheels are red.
- Discuss the group’s findings.
 - Which car traveled the farthest?
 - Which design option made the car travel farther? Or are the 2 options the same?
- Discuss with the students which distances are almost the same (and call them a “tie”) and which distances have a big enough difference that they are not a “tie”.
 - It’s possible that factors other than the part you are testing will vary between cars, beyond what you can control in setting up a fair test. For example, the rubber band on one car could be worn out; the wheels could spin more easily on another. And of course, human error enters the equation: students could push the car instead of releasing it freely, or incorrectly record results.
 - Even the same car will produce slightly different results between trials.
 - Results within 10 cm could be considered a tie and can be explained by these minor differences. Results that are half a meter or more apart could be considered conclusive.

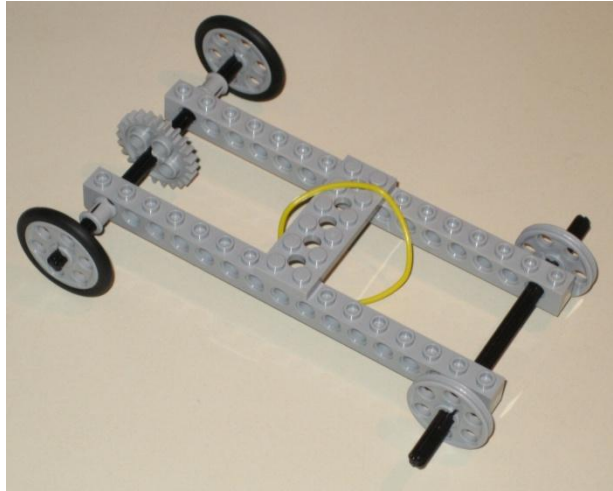
Part 1: Building Rubber-Band Cars

- **Focus Question:** How can you describe different properties of cars?
- **Initial Discussion:**
 - Discuss with the students the properties of a car:
 - What parts make up a car? (wheels, doors, engine, etc)
 - What are the different sizes and shapes of cars? (you can discuss this by comparing different types of cars – e.g. trucks are longer than family-type cars; minivans are bigger than sports cars... discuss all 3 dimensions of cars – length, width, and height)
 - What other properties can you measure about the car? (Discuss different ways you can measure a car's performance – e.g. how fast the car is; how long it can drive before refilling the gas; how quickly it can fully stop, etc)
 - Explain that in these experiments, you will build a rubber-band powered LEGO car. You will test out cars with different properties (i.e. different parts) and measure which cars travel a greater distance (i.e. go farther).
- **Build a Rubber Band Car**
 - You can pair up students and each group builds a car, or you can build the car together as a whole group with the teacher leading.
 - (see Building Instructions section)
- **Test the Rubber Band Car**
 - Wind it up and release it to try a run.
 - If time permits, have each student take a turn winding and releasing the car.
 - First, load the rubber band onto the gear, while the car is on the ground.
 - Then pull the car backward on the ground to wind the rubber band around the gear. Wind for 1 full rotation of the wheels, until the rubber band is lined up straight across the gear like this:

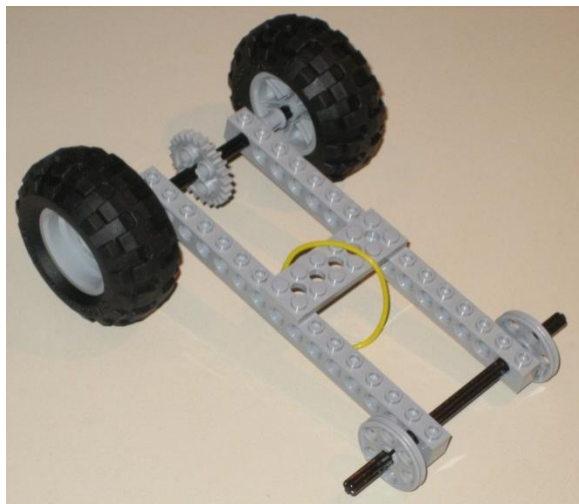


Part 2: Wheels

- **Focus Question:** Does wheel size change the distance that the car travels?
- **Design Option #1:** use the small, thin wheels with the thin rubber treads



- **Design Option #2:** use the bigger, thicker wheels with the thick rubber treads



- **Typical Results:** Larger wheels typically make the car go farther

Extension Activities

Extend the students' learning by having students analyze how additional design changes such as rubber band power, weight, size and wheels will affect the distance their cars will travel.

Activity 1: Rubber Band Power

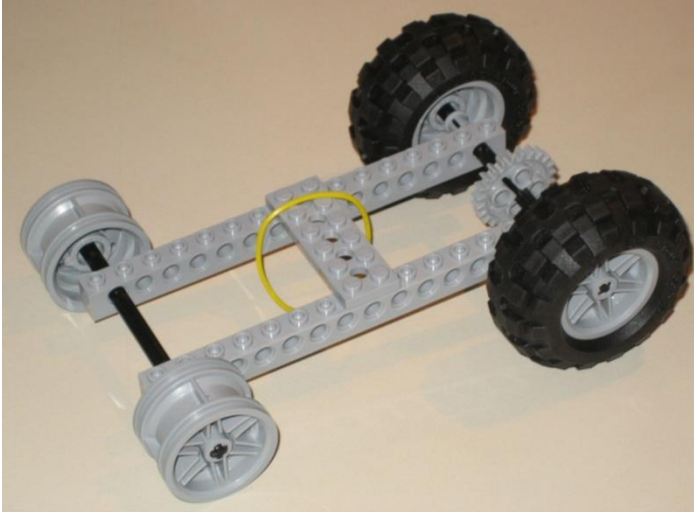
- **Focus Question:** Does changing the way the rubber band is wound up change the car's distance?
- **Design Option #1:** wind the rubber band around for 1 full rotation of the wheels
- **Design Option #2:** wind the rubber band around for 3 full rotations of the wheels
 - Be careful that the rubber band doesn't snap – wind slowly and don't wind more than 3 rotations.
- **Typical Results:** The more you "wind up" your car, the more energy the rubber band stores and propels your car farther
- **Optional variation:** Test one rubber band versus two rubber bands – double up the rubber bands used in the drive train. Does this help your car go farther?

Activity 2: Weight

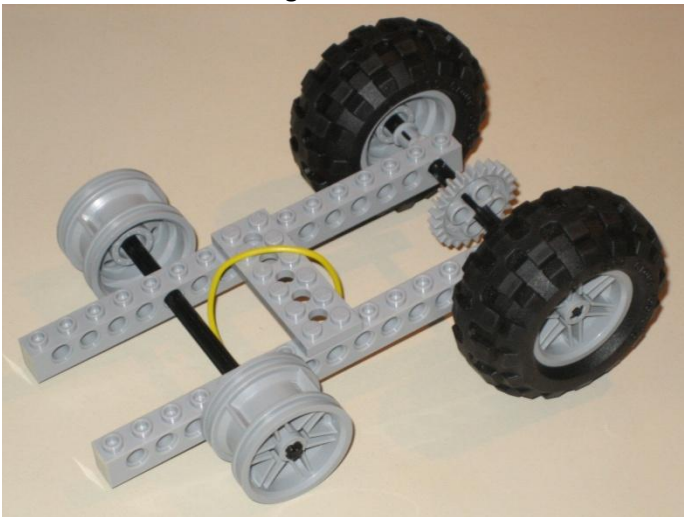
- **Focus Question:** Does changing the car's weight make the car travel a different distance?
- **Design Option #1:** Build the regular Rubber Band Car without extra weight
- **Design Option #2:** add some weight to the car (a soda can or some batteries, attached with tape or a LEGO-constructed 'basket').
- **Typical Results:** More weight will make the car travel shorter distances because it takes more energy to move that extra weight.
 - Is it harder to run with or without a heavy backpack full of books? Ask the students to imagine doing this and use that comparison to explain the results of this experiment.

Activity 3: Car Size

- **Focus Question:** Does placing the front and back wheels closer together change the distance the car travels?
- **Design Option #1:** Build the regular Rubber Band Car with the front wheels at the end of the longest LEGO beams. Instead of the small wheels for the front, use the larger wheels without the rubber treads:



- **Design Option #2:** Move the front wheels closer to the back wheels. Put their axle 5 holes from the front end on the long LEGO beam.



- **Typical Results:** Changing the distance between front and back wheels typically will not show much difference in distance traveled.
- **Optional variation:** Change the car to make it wider. Does that make the car go farther, have no effect, or lessen the distance traveled?

Activity 4: Wheel Surface & Friction

- **Focus Question:** How does changing the surface of the wheels affect the distance the car travels?
 - Friction between the wheels and ground (also called traction) helps propel the car forward. If there were no friction (imagine being on super slippery ice) the wheels would just spin, and the car wouldn't be able to move forward.
- **Design Option #1:** Build the regular Rubber Band Car with the big wheels on the back with their rubber treads on.
- **Design Option #2:** Remove the rubber treads from the back wheels.
- **Typical Results:** The rubber treads have more traction with the ground and make the car go farther. The plastic surface of the wheels (without treads) has less traction with the ground. They spin in place more when releasing the car.
 - Is it easy to start running on ice? Or wearing socks on a slippery floor? Compare this to the plastic wheels having no traction on the ground and spinning in place.