Motion Commotion, L1, Activity 1:Differential Gears

Subject Area **Measurement**

Associated Unit **Mechanics Mania**

Associated Lesson Motion Commotion

Activity Title **Differential Gears**

Header Insert image 1 here, right justified to wrap

Image 1

ADA Description: A LEGO four-by-four using with a differential gear

Caption: Figure 1. Student adjusting a differential gear

Image file name: Student_Gears_Image_1.jpg

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Grade Level 4 (3-5)

Activity Dependency None

Time Required 30 minutes

Group Size 2 to 3

Summary

The goal of this activity is to teach elementary school students how differential gears work and how they can be constructed using a LEGO NXT ® kit. The students will construct two different chassis; one with a gear differential and one without. They will then experiment with turning and discuss different styles of gears and how they can be used for different functions.

Engineering Connection

Differential gears are device employed by cars and trucks to assist in turning corners. When cars are turning corners, the inside wheels are traveling a shorter distance than the outside wheels, the differential gear allows this turning to be smooth. These gears are employed not only in cars and trucks but also in locomotive robots.

Engineering Category

(3) Provides engineering analysis or partial design

Keywords

Differential Gears, Gears, LEGO, mechanics, robotics, torque

Educational Standards

- New York Science (1996): T 1.1, T 1.4, T 1.5

Pre-Requisite Knowledge A familiarity with gears, simple mechanics and basic geometry.

Learning Objectives

After this activity, students should be able to:

- Engineer and design a differential gear system using standard LEGO parts
- Describe the importance of a differential gear in auto mechanics

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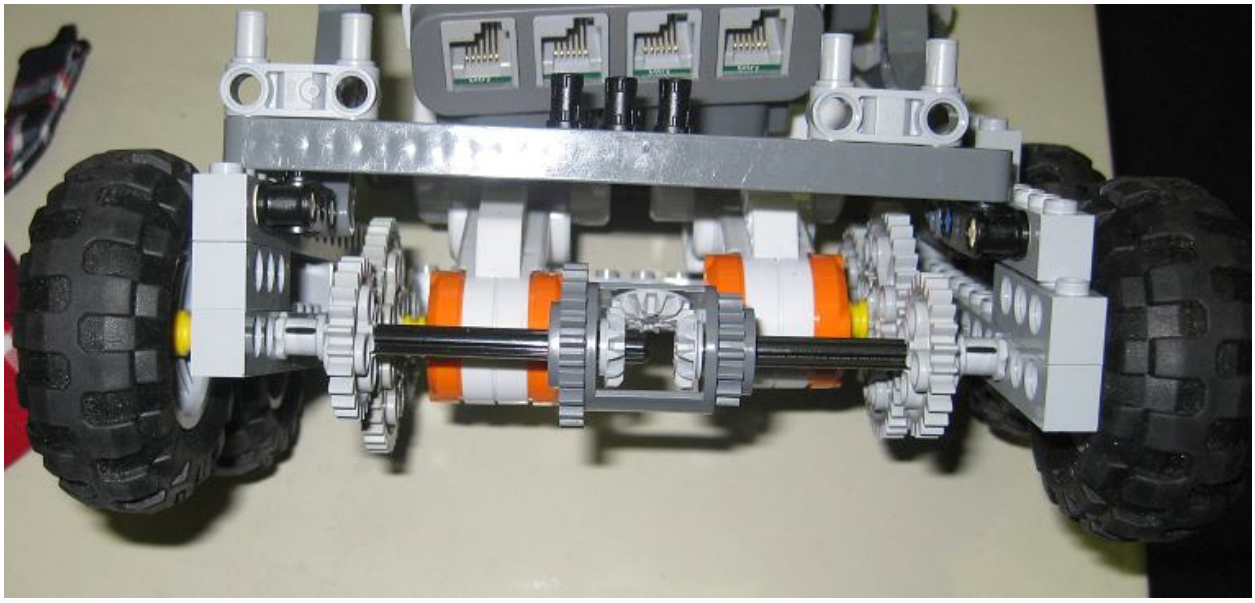

Image 2

ADA Description: Close up for 4X4 utilizing a differential gear.

Caption: none

Image file name: Differntial_Gear_Image_2.jpg

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Materials List

- LEGO NXT® kit
- LEGO Technic® Resource kit
- Baby Powder
- Black sheet of paper
- Length of string
- Ruler (centimeters)

Introduction / Motivation

Have you ever noticed in a track race, that the runners do not start in the same position? (Draw on the classroom board a mock race track with staggered starting positions). Why is it fair that all

the runners end at the same line but those closer on the inner part of the circle start further back than those on the outer part of the circle. Do you think in the end the runners run the same distance or that those in the starting positions further from the center run shorter distances? What would happen if we had all the runners start at the same line, who would have the advantage? From these questions you want the students to garner an understanding that the distance around the circle (or in this case an oval) is greater as you move further away from the center.

From Math class we are familiar with the circumference of a circle, or the distance around the circle. We learned that when you multiply the diameter of the circle by π , we get the circumference. Do the runners on the outside of the track have a larger or smaller diameter then those on the inside? If the runners have a larger diameter, will they have a larger or smaller circumference? The runners on the inside of the track have a smaller circumference then those on the outside. Therefore, to make sure that everyone has to run the same distance the runners on the inner part of the track have to start further back than those on the outer part of the track.

Now, let's think about a car going around a turn (a helpful trick would be to take a Matchbox ® car and drive it around the track which is already drawn on the class room board). When we move our car around the track will the wheels on the inside of the car travel a shorter distance than those on the outside?

We have previously learned that speed =distance/time, if the car is traveling for the same amount of time but the distance for the outside wheels is greater than the inside wheels, what sort of consequences do you think that would have?

To overcome this limitation automotive engineers use a special kind of gear called a "differential", in today's activity, we are going to use LEGO parts to build two different chassis; one with a gear differential and one without. After that we are going to examine how these different chassis turn.

Vocabulary / Definitions

Word	Definition
Chassis	The framework which supports manmade objects.
Differential Gear	any of various comparable arrangements of gears,
Torque	something that produces or tends to produce torsion or rotation; the moment of a force or system of forces tending to cause rotation.

Procedure

Background

A differential gear is a device which allows the engine torque to be split in two ways. This device allows for the wheels to spin at different speeds. Many people have been credited with the invention of differential gears but it is most commonly attributed to Rudolph Ackermann (1810).

The differential gear is employed by most cars and trucks we find on the road today. When an automobile is moving straight, the differential gears do not rotate with respect to their axes.

However, when the automobile is negotiating a turn the differential allows for the two wheels to rotate differentially with respect to each other.

The importance of differential gears is highlighted but examining the turning efficiency of those vehicles which do not employ differential gears. The typical shopping cart found in the grocery store does not use a differential gear therefore; the driving wheels rotate at the same speed. When moving in a straight line there is no problem but when cornering the inner wheel needs to travel a shorter distance then the outer wheel. This result in the inner wheel spinning and the outer wheel is dragging.

With the Students

- Divide the class into groups of three to four students

Distribute to each group the required parts and instructions as described in the Construction_without_differential_gears.pdf AND Construction_with_differential_gears.pdf

- Concomitantly, hand out the baby powder and the black paper.
- Give the students roughly ten minutes to construct both chassis as described in the attached construction out lines. After this is concluded each group should have two chassis as shown in figure 1(A&B).

Image: Insert Image3 here, center justified to wrap

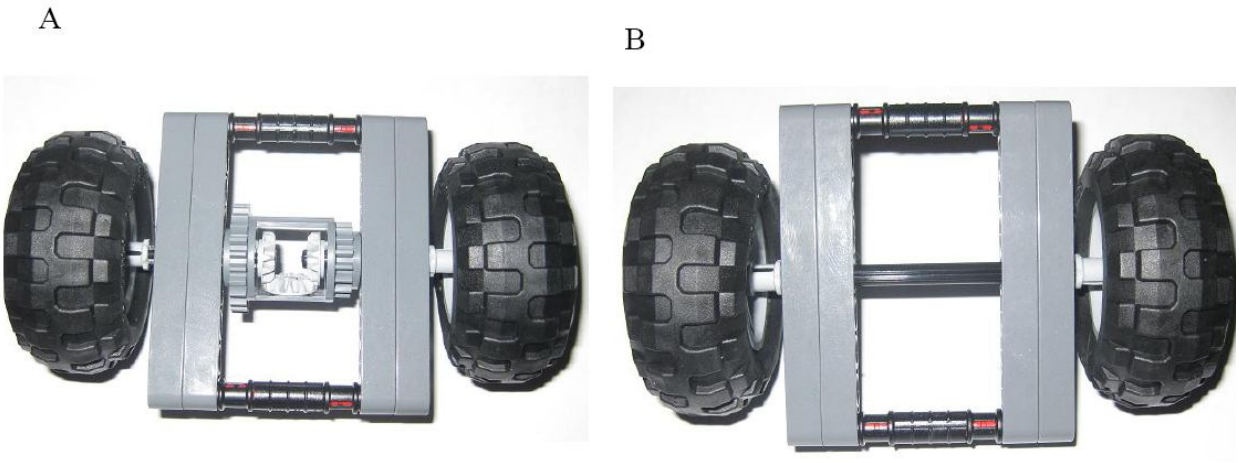

Figure 1
ADA Description: Comparison of the two different chassis constructed by the students
Image file name: Comparsion_Figure1.jpg
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- Allow the students to hold the chassis in their hands and rotate the wheels, in a class room wide discussion they are asked to explain their observation.
- The students are then asked to dust all four wheels in chalk dust and push them along the black paper as if they were going around a race track.

- The students are then asked to observe the differences in the track marks between the two different chassis.
- Instruct the students to use both chassis to make both right-hand and a left-hand turns.
- Have the students lay a piece of string on the tracks of both the inner and outer wheels
- They should measure and record the lengths of the inner and outer wheel tracks

Attachments

Construction_without_differential_gears.pdf

Construction_with_differential_gears.pdf

Safety Issues

- None

Troubleshooting Tips

- None

Investigating Questions

- None

Assessment

Pre-Activity Assessment

Questions: The students are asked a series of questions during the classroom introduction of this activity.

- Why is it that during a track race, the runners on the inner part of the track start further back than those on the outside?
- Knowing that Speed = distance/time, if a car travelling around at the same speed around a curve for the same time, what do you expect will happen to distance and how will that relate to the cars ability to turn.

Activity Embedded Assessment

Discussion: During the activity the students are asked in a class room wide discussion to describe their observation.

Post-Activity Assessment

Engineering: In a class room discussion the students are asked to discuss their results and the difference between the two patterns. The students are asked is the can think of any everyday item which could be improved by a differential gear (shopping carts)
Based on their results, you can revisit the discussion about why there is a staggered starting arrangement in races.

Activity Scaling

- For upper grades, this activity can be used to calculate the angular velocity using the equation (Iav1+Iav2)/2 =Oav, where Oav equals the output angular velocity and Iav1 and Iav2 equal the input angular velocities.

Additional Multimedia Support

http://www.youtube.com/watch?v=K4JhruinbWc#t=1m50s&feature=related

http://auto.howstuffworks.com/differential2.htm

References

Astolfo, D. LEGO Mindstorms NXT. Burlington, MA: Syngress Publishing, Inc. (2007)

Dictionary.com . Lexico Publishing Group, LLC. Accessed February 1, 2010 (Source of some vocabulary definitions, with some adaptations) http://www.dictionary.com

Redirect URL

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Owner

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