Gears: Determing the angular velocity

Subject Area(s):	Physics, mathematics, measurement, and engineering
Associated Unit:	None
Associated Lesson:	None
Activity Title:	Gears: Determining the angular velocity
Header:	Insert image 1 here, right justified to wrap

Image 1

ADA Description: Students getting their experiment ready, for example preparing the robot, fixing the gears, setting up the light sensor

Caption: Students preparing the robot to determine angular velocity

Image file name: gearlightrobot_image1.jpg

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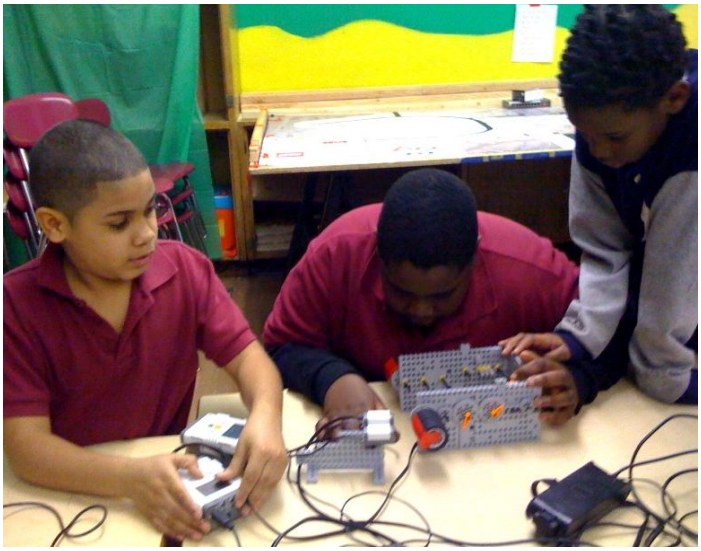

Level:	5 (4 and 6)
Activity Dependency:	None
Time Required:	50 minutes
Group Size:	Twenty
Expendable Cost per Group	US $5.00

Insert Image 2 here, centered

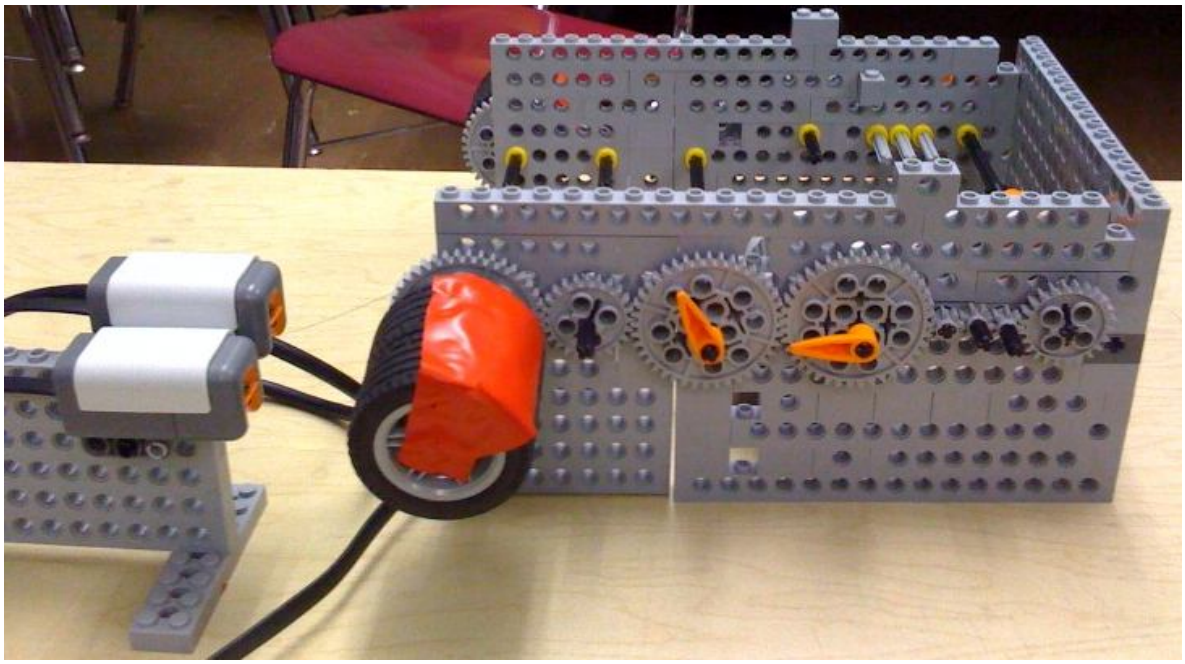

Image 2

ADA Description: One of the robot designs that will be used for determining angular velocity of gears

Caption: Gear robot with light sensor

Image file name: Gearlightrobot_image2.jpg

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Insert Image3 here, centered

Image 3

ADA Description: Students setting up the data logging program in conjunction with the light sensor

Caption: Gear experimental set up

Image file name: gearlightrobot_image3.jpg

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Summary
Students will work as engineers and learn to conduct controlled experiments by changing one experimental variable at a time and study its effect on the outcome of the experiment. Specifically, they will conduct experiments to determine the angular velocity for a gear train with varying gear ratios and lengths. First, the students will assemble a robot with various size gears in a gear train. Second, they will design a program in NXT MindStorm that will cause the motor to rotate all the gears in the gear train. Third, students will use MindStorms Data Logging Program to setup their experiment with the light sensors. Fourth, they will run the program with the motor and the light sensor at the same time. Fifth, they will analyze the plot from MindStorms Data Logging Program and determine the angular velocity with a physics based formula. Sixth, they will manipulate the gear train with different gears and different lengths. Finally, students will analyze all these factors and figure out which manipulation has a higher angular velocity.

Engineering Connection
Students will learn to design a setup for engineering experimentation. Specifically, they will design their own robot and write their own programs for the robot and determine the angular velocity. Moreover, by changing the design of the robot they will figure out what design features will help increase the angular velocity. They will change gears and number of gears to optimize angular velocity.

Engineering Category

Relates physics concepts to engineering

Keywords
Gear, gear train, angular velocity, robot

Educational Standards
- New York State Standards
  - New York science: 4.4, 4.5
  - New York math: 3.1, 3.2, 3.3, 3.5
  - New York Technology 5.1, 5.3, 5.4

Pre-Requisite Knowledge: Division, multiplication, and basic concept of function

Learning Objectives
After this activity, students will be able to:
- Design a Lego robot with a gear train
- Program a robot with NXT MindStorms software
- Design a gear train with two different types of gears with a specified number of gears

- Open up MinStorms Data logging program with light sensor and record the amount of times the red light is sensed with the light sensor

Insert Image 4 here, centered

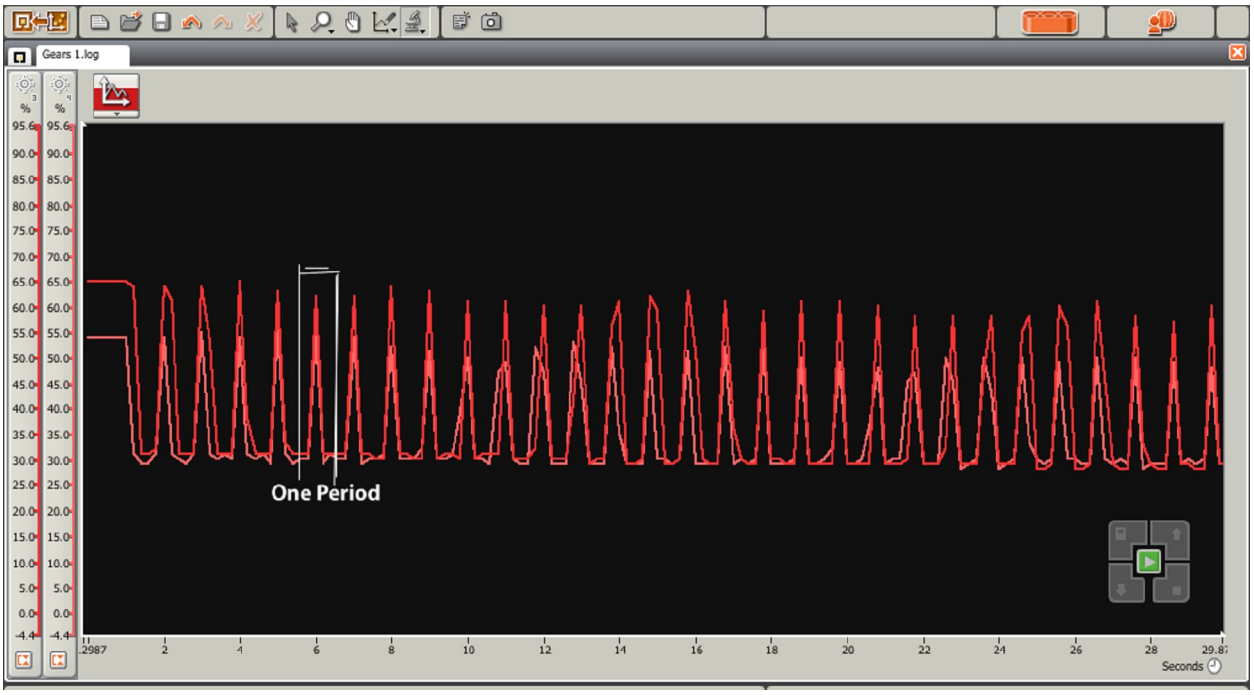

Image 4

ADA Description: Result observed from the Data logging program from NXT Mindstorms

Caption: Mindstorms Data logging experimental result

Image file name: gearlightrobot_image4.jpg

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- Calculate the angular velocity of the rotating gears using the light sensor to detect the rotation of the wheel the with the formula below:

  Angular Velocity (radians/sec)= 2*Pi(radians)/Period (sec) (Eq. 3)

  One period is the amount of time it takes for the wheel to do one full rotation. This is determined using the NXT MindStorms Data logging Program as outlined in the instructions.

- Change one variable at a time and examine its effect on the angular velocity

Materials List

Each group needs:

- Lego NXT Kit
- Two NXT bricks
- Calculator
- Ruler
- Two pieces of electrical tape (not including black)

To share with the entire class:

- Computer with NXT MindStorms programming software
- Computer with NXT MindStorms Data logging Program

Introduction / Motivation

The term speed is often used to describe how fast an object can travel. Here we will try to determine how fast a set of gears turn are on a gear train. To do so, we will use a light sensor with the MindStorms Data logging program. Then, we will adjust the types of gears and the length of the gear train and determine the angular velocity for each of the different types of gear trains. Students will determine the optimal gear train based on the fastest angular velocity achieved.

Students love watching cars moving fast. Gears are important for the movement of vehicles. In this experiment, they will learn about all the math and science that goes into the angular velocity of a gear train. They will make their own robotic creations and their own program that will cause a robot gear train to spin fast. Students will also learn the importance of each variable in the outcome of the experiment. They will change one variable at a time and determine which variable will make the gear train have the highest angular velocity.

Vocabulary/Definitions

Word	Definition
Period (sec)	The length of time to complete one cycle
Gear	A rotating machine with cut teeth
Gear Train	A set of gears that are able to transfer rotational motion
Circumference (cm)	The distance around a circle.
Degrees	The unit of measure for a given angle
Radians	The unit of measure for a given angle equal to 57.296 degrees
Linear Velocity (cm/ Sec)	The distance traveled per unit time
Radius (cm)	The length of a straight line segment from the center of the circle to

	the circumference of the circle.
Diameter (cm)	The length of a line segment passing through the center of a circle and intersecting both sides of the circle.
Angular Velocity (radians/ sec)	Rate of change of angle with time.

Procedure

Before the Activity

1. Have the students design their own robot that will be used to calculate angular velocity.
2. Have the students program the robot and show that they can rotate a set of gears in a gear train.
3. Go over MindStorms Data logging program and show how the light sensor works in the program. Refer to the program
4. Teach the students circumference, units for circumference, velocity, and angular velocity. Go over the physics based formulas with them.
5. Ask students what they think will happen to the angular velocity when they change the gear length and gear ratio in the gear train.
6. Ask students to start with two different gears (i.e. a big and a small) in the gear train and then they can try other gear ratios.
7. Divide students into groups and assign each group member a task.
8. Make sure each student has the handout for the activity.

With the Students

1. Show the students various gears and have them make observations.
2. Have the students design their gear train robot with two gears. Next, have them create their program using the Lego MindStorms software. They should look at all two-gear systems with different gear ratios first.
3. Have the students work with the light sensor in MindStorms Data logging program. The light sensor takes in ambient light and is able to distinguish between dark and light colors. It can simply measure the intensity of the different lights and can be programmed to react to a particular intensity. The light sensor will detect time instances when the strip of white or orange tape on the wheel comes into view of the sensor. The data logging software will show those instances on a time plot as spikes in the detected light intensity.
4. Take the gear train and connect it to a motor with a taped wheel at the end shown in image 2.
5. Measure the period for each type of gear train using the MindStorms Data logging program. (Be sure to look at Image 4 for reference).
6. Once all data has been obtained for two-gear systems, begin to change the variables, one at a time.

7. First, change the number of gears in the gear train, and determine the angular velocity using the Lego MindStorms Data logging program and the physics based formulas.
8. Next, change the gear ratio for the length of interest and determine the angular velocity using the Lego MindStorms Data logging program and the physics based formulas.
9. Have the students discuss what they have learned from the experiment and have them fill out their conclusions in the lab report.

Attachments

Angular Velocity_Teach Engineering.doc
Angular Velocity_Teach Engineering handout.doc
gearlightrobot_image1.jpg
gearlightrobot_image2.jpg
gearlightrobot_image3.jpg
gearlightrobot_image4.jpg

Safety Issues

- Be careful not to poke fingers into gears when MindStorms program are running

Troubleshooting Tips

Make sure that the periods are accurately determined in the MindStorms Data logging program

Investigating Questions

Which gear train had the highest angular velocity for the two-gear system? Why?
What happened to the angular velocity when the length of the gear train was increased?
For a four gear train, what gear ratios would be best to use to obtain a system with a high angular velocity?

Assessment

Pre-Activity Assessment

Guessing game: Ask them to predict which set of gears in the two-gear train system will have the highest angular velocity.

Activity Embedded Assessment

Design a robot: Tell the students to make a two-gear system gear train. Ask them if they can show you how the gear train works?

Post-Activity Assessment

Tuning the equation: Challenge the students and ask them to change the gears in the gear train and the length of the gear train. Ask them what gear train is optimal for a high angular velocity.

Activity Scaling

- For lower grades: None
- For upper grades:

  Calculate the linear velocity of the wheel's outer surface. (velocity of a point on the circumference of the wheel). Use the following formula: linear velocity(cm/sec)=angular velocity(radians/sec) * radius(cm). Do this for various gear configurations.

Additional Multimedia Support

None

References

Hewitt, Paul. Conceptual Physics. New Jersey: Prentice Hall, 2002.

Zitzewitz, Paul. Physics Principles and Problems. Ohio: McGraw-Hill, 2002.

Other

None

Redirect URL

http://gk12.poly.edu/amps/

Owners

Jennifer S. Haghpanah

Contributors

Jennifer S. Haghpanah, Leonarda Huertas, Jasmin Mejias, Mihai Pruna

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